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COCHRANE FLOODPLAIN STUDY

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CANADA - ALBERTA FLOOD DAMAGE REDUCTION PROGRAM

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COCHRANE FLOODPLAIN STUDY

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CANADA - ALBERTA FLOOD DAMAGE REDUCTION PROGRAM

ADDENDUM

COCHRANE FLOODPLAIN STUDY

(NOVEMBER, 1990)

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1.0 INTRODUCTION

In April, 1989, Canada and Alberta signed "An Agreement Respecting Flood Damage Reduction and Flood Risk Mapping in Alberta". This agreement initiated the Canada - Alberta Flood Damage Reduction Program (FDRP) which provides for the identification and mapping of flood risk areas in urban communities across the province. The Cochrane Floodplain Study (1986) was accepted as meeting the basic requirements of the FDRP with respect to hydrologic analysis, surveys and mapping standards. However, it was felt that the existing maps, which identified an ice hazard zone as well as an open water flood risk area for the Bow River, should be revised to include a two-zone (floodway/flood fringe) designation. This would be consistent with flood risk mapping currently being produced for other Alberta communities under the FDRP.

This addendum describes the approach used to develop the revised two-zone flood risk maps for the Bow River - Cochrane to Bearspaw Dam Reach. To reduce the potential for flood damages in the study reach it is recommended that these maps form the basis for regulating all future development in the flood prone areas.

2.0 TERMINOLOGY

The following terminology has been adopted by the FDRP Technical Committee.

2.1 Flood Risk Area

The flood risk area is the area which would be inundated by the design flood. In Alberta the adopted design flood is the so called 1:100 year flood which is an extreme event having a one percent chance of being equalled or exceeded in any year.

The flood risk area includes the floodway and the flood fringe. These two terms are defined below.

2.2 Floodway

The floodway is that portion of the flood risk area where the flood waters are deepest, fastest and most destructive. It is a constricted channel area within which the entire design flood can be conveyed without raising water levels or increasing flow velocities beyond specified limits. The criteria used to determine the physical limits of the floodway are described in Section 3.1.

2.3 Flood Fringe

The flood fringe is the outer portion of the flood risk area. The water in this zone is shallower and flows more slowly than in the floodway. Conditions are generally less hazardous than in the floodway.

2.4 Designation

As flood risk maps are completed, the federal and provincial ministers responsible for the FDRP will designate the flood risk area as a zone wherein certain government policies will apply.

3.0 FLOODWAY DETERMINATION (BOW RIVER)

3.1 Hydraulic Criteria

Under the FDRP the following hydraulic criteria have been adopted for determining floodway limits:

1. The water surface profile shall not exceed 0.3 m (or less as specified by the Technical Committee for Canada-Alberta FDRP) above the profile for the design flood under existing floodplain conditions.

2. In general, all areas where the depth of flooding exceeds 1 m or the velocities are above 1 m/s, shall become a part of the floodway. However, in order to achieve an hydraulically smooth floodway boundary, some areas with depths exceeding 1 m and velocities exceeding 1 m/s will inevitably become part of the flood fringe.

3. In river reaches where the existing mean channel velocities are excessive, the encroachments for the floodway the should be minimized so that the existing velocities are not further increased.

4. In reaches of supercritical flow no encroachment shall be introduced.

5. In the case of ice jam flooding, areas with depths of flooding of 1 m or more shall become a part of the floodway.

These criteria are intended to limit the flood hazard in the flood fringe and to minimize increases in upstream water levels. They are generally referred to as the depth-velocity-rise criteria.

3.2 Approach

Normally the design flood for any water course is represented by the 1:100 year open water (summer) flood condition. In the case of the Bow River (Cochrane to Bearspaw Dam Reach), however, the analysis showed that the 1:100 year ice flood (winter) condition presented a much greater flood hazard. Consequently, the 1:100 year ice flood was selected as the design flood for this study.

In determining the floodway limits along the Bow River the approach taken was simply to apply the one metre depth criterion, as defined in the previous section, to the design (ice) flood levels (i.e., areas flooded to a depth greater than 1.0 m were assumed to be part of the floodway). Since no model existed to adequately simulate the ice flood condition [1] the inpact on flow velocity and flow depth could not be assessed in a rigorous fashion. Instead, it was reasoned that:

a) Since severe ice flooding on the Bow River is essentially created by a "backed up" flow condition (caused by ice blockage and added roughness in the main channel) it is unlikely that velocities in the "fringe" areas would exceed the one metre per second velocity criterion.

---

[1] The U.S. Corps of Engineers' computer program (HEC-2), which was used to compute water surface profiles for open flow conditions, has the additional capability of determining water levels produced by a stationary floating ice cover. This feature of the HEC-2 program was considered inappropriate for this study since the unstable ice conditions which produce the critical water levels in the Bow River (Cochrane Reach) cannot be adequately represented by this model given the underlying assumption of a stationary floating ice-cover (see Section 2.5 of the main report).

b) The loss of the "fringe" area, should it become fully developed, should not have a major impact on water levels since the percentage of the total discharge which would be carried through the fringe areas is very small in comparison to the total capacity of the floodway.

It is worth noting that with the exception of a small area below the confluence with Jumpingpound Creek the floodway, as determined by the one metre depth criterion, does not encroach upon the 1:100 year open water flood limits. Thus, summer flood levels will not be impacted by the proposed designation.

3.3 Computed Water Levels

The computed water surface profiles for the 1:100 year ice flood (design flood) are plotted in Figure 4 of the main report along with the 1:100 year open water (summer flood) profile. For convenience the computed water levels for these events are presented in Table 1 of this addendum.

3.4 Flood Risk Maps

The revised Flood Risk Maps for the Bow River (Cochrane to Bearspaw Dam Reach) are presented in Figure 7 (Sheets 2-10) of the main report. These maps show the proposed two-zone (floodway/flood fringe) designation in addition to the information originally presented on the maps produced for the 1986 study.

4.0 TRIBUTARY STREAMS

4.1 Approach

The 1986 Cochrane Floodplain Study included the lower reaches of Jumpingpound Creek and Bighill Creek which both enter the main stem (Bow River) at Cochrane. Both of these streams have relatively small floodplains which are confined to narrow valleys. In the case of Bighill Creek, the reach within the Cochrane town limits flows through an area which has been set aside as environmental reserve.

Taking the above into consideration it was decided that two-zone flood risk mapping for the tributary streams was not required and that a single flood risk designation would be more appropriate.

4.2 Computed Water Levels

The computed water surface profiles for the 1:100 year design flood (open water) on Jumpingpound Creek and Bighill Creek are plotted in Figures 5 and 6, respectively of the main report. For convenience, the computed water levels for these events are presented in Tables 2 and 3 of this addendum.

4.3 Flood Risk Maps

The revised Flood Risk Maps for Jumpingpound Creek and Bighill Creek are presented in Figure 7 (Sheets 11 & 12) of the main report. These maps show the proposed single zone (floodway) designation in addition to the information originally presented on the maps produced for the 1986 Study.

5.0 HEC-2 MODEL INPUT/OUTPUT

Complete listings of the HEC-2 model input/output files (final 1:100 year runs) for the Bow River, Jumpingpound Creek and Bighill Creek are provided in Appendix E of the main report.

TABLE 1

COMPUTED WATER SURFACE ELEVATIONS
(BOW RIVER)

X-Section [1] Number	1:100 Year Flood Level (m) Open Water [2] (Summer Flood)	1:100 Year Flood Level (m) Ice [3] Flood
1	1090.60	1091.2
2	1091.21	1092.4
3	1091.61	1093.2
4	1093.27	1094.8
5	1093.66	1095.1
6	1094.34	1095.6
7	1094.76	1096.2
8	1095.86	1097.4
9	1097.27	1098.3
10	1097.53	1098.9
11	1098.59	1099.8
12	1098.90	1100.4
13	1099.62	1101.4
14	1100.60	1101.9
15	1100.94	1102.6
16	1103.15	1104.8
17	1104.90	1105.9
18	1105.00	1106.0
19	1105.51	1107.0
20	1106.25	1107.8
21	1106.65	1108.6
22	1107.84	1109.3
23	1108.14	1110.0
24	1108.91	1110.8
25	1110.22	1111.9
26	1110.39	1112.4
27	1111.46	1113.2
28	1111.81	1114.4
29	1113.90	1115.2
30	1114.13	1116.0
31	1114.02	1116.6
32	1116.04	1117.8

TABLE 1 Con't.

X-Section [1] Number	1:100 Year Flood Level (m) Open Water [2] (Summer Flood)	Ice [3] Flood
33	1116.45	1118.4
34	1117.31	1119.2
35	1118.10	1119.7
36	1118.14	1119.8
37 (Bridge)	-------	------
38	1118.29	1119.9
39	1118.48	1120.0
40	1118.73	1120.6
41	1119.91	1121.6
42	1119.77	1122.2
43	1121.78	1123.4
44	1122.07	1124.3
45	1122.39	1124.4
46 (Bridge)	-------	------
47	1123.06	1124.5
48	1123.60	1124.8
49	1124.11	1125.6
49.1	1124.05	1126.5
50	1125.95	1127.2
51	1126.45	1128.4
52	1127.27	1129.5
53	1128.17	1130.4
54	1129.99	1131.5
55	1130.65	1132.7
56	1130.83	1133.0
57 (Bridge)	-------	------
58	1131.29	1133.0
59	1131.31	1133.1

---

[1] Cross-section locations are shown on Flood Risk Maps, Figure 7, main Report.

[2] See Calculation of Flood Levels - Open Water Conditions, Section 4.0, Main Report.

[3] See Calculation of Flood Levels - Winter Ice Conditions, Section 5.0, Main Report.

TABLE 2

COMPUTED WATER SURFACE ELEVATIONS (JUMPINGPOUND CREEK)

X-Section [1] Number	1:100 Year [2] Flood Level (m)	X-Section Number	1:100 Year Flood Level (m)
1	1125.63	12	1137.69
2	1126.74	13	1138.46
4	1128.31	14	1141.39
5 (Bridge)	-------	15	1143.36
6	1128.59	16	1144.45
7.1	1129.18	17	1146.86
8	1130.59	18	1148.80
9	1131.72	19	1149.93
10	1133.13	20	1151.76
11	1136.18	21	1153.99

---

[1] Cross-section locations are shown on Flood Risk Maps, Figure 7, Main Report.

[2] See Calculation of Flood Levels - Open Water Conditions, Section 4.0, Main Report.

TABLE 3

COMPUTED WATER SURFACE ELEVATIONS (BIGHILL CREEK)

X-Section [1] Number	1:100 Year [2] Flood Level (m)	X-Section Number	1:100 Year Flood Level (m)
1	1156.02	14	1139.43
2.1	1155.68	15.1	1139.21
(Bridge)	-------	(Bridge)	-------
2.4	1155.54	15.4	1139.09
3	1155.28	16	1138.32
4	1153.25	17	1136.73
5	1150.19	18	1134.43
6	1147.87	19.1	1133.48
7	1145.06	(Bridge)	-------
8	1142.91	19.4	1132.87
9	1141.29	20	1132.10
10.1	1140.94	21	1128.67
(Bridge)	-------	22	1125.89
10.4	1140.91	23	1124.97
12.1	1140.76	(Bridge)	-------
(Bridge)	-------	25	1124.90
12.4	1140.73	26	1122.37
13	1140.58	27	1122.00

---

[1] Cross-section locations are shown on Flood Risk Maps, Figure 7, Main Report.

[2] See Calculation of Flood Levels - Open Water Conditions, Section 4.0, Main Report.

COCHRANE FLOODPLAIN STUDY

MAIN REPORT

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COVER:

BOW RIVER ICE PACK AT THE RIVER AVENUE
BRIDGE IN COCHRANE - FEBRUARY, 1982
ALBERTA ENVIRONMENT PHOTO

JUNE, 1986

Alberta
ENVIRONMENT

WATER RESOURCES MANAGEMENT SERVICES
TECHNICAL SERVICES DIVISION

SUMMARY

This report contains the results of a detailed hydrologic and river hydraulics study, which has been carried out to delineate the flood risk areas for the 1% (1 in 100 year) flood on the Bow River (Cochrane to Bearspaw Dam reach), and on Jumpingpound and Bighill Creeks near the Town of Cochrane. In addition, an ice hazard zone has been delineated on the Bow River, based on an analysis of several years of winter ice pack observations.

The ice hazard/flood risk delineations for the study area are shown on 1:5,000 scale orthophoto maps. Calculated water surface profiles for the 1% flood and other flows are included, as is the approximate backwater profile for 1 in 100 year ice pack conditions on the Bow River. Brief descriptions of those areas situated in the ice hazard/flood risk zones are presented.

One of the most important conclusions arising from this study relates to the finding that winter flooding due to ice jams on the Bow River can reach significantly higher levels than spring or summer floods. Thus, governments and the private sector alike, must recognize the very real potential for winter flooding when planning future development along the Bow River within the study reach.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. P. Doyle from TransAlta Utilities Corporation and Mr. T.M. Schulte, formerly with Calgary Power Ltd., for providing valuable information on ice pack observations on the Bow River.

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1.0 INTRODUCTION

In recent years there have been several major residential/industrial subdivision proposals adjacent to the Bow River at Cochrane. This development activity has created a need for a comprehensive floodplain study, which would designate flood hazard zones, as well as provide the technical information necessary to formulate floodplain management alternatives and assess the impact of future land use proposals on the river system. Interest in such a study has been expressed by both the Town of Cochrane and the Calgary Regional Planning Commission, as well as the Land Use Branch, Alberta Environment.

1.1 Study Objectives

The purpose of this study is to delineate flood risk areas along the Bow River between Cochrane and the Bearspaw Dam, and along Jumpingpound and Bighill Creeks at Cochrane. Specific objectives include determining the areal extent of the 1 in 100 year open water flood, as well as the potential for winter flooding due to ice jams.

1.2 Study Area

The study area encompasses primarily undeveloped land bordering the Bow River between the CPR crossing located about 3 kilometres (km) west of Cochrane and the Bearspaw Dam located just outside the western limits of the City of Calgary (Figure 1). The total length of river involved is approximately 27 km.

The section of Jumpingpound Creek within the study area encompasses the reach starting at its confluence with the Bow River, and ending at the south boundary of Sec 33-25-4-W5 (approximately 5 river km). The study limits along Bighill Creek extend from its confluence with the Bow River, north through the Town of Cochrane as far as the east boundary of Sec 10-26-4-W5 (approximately 4.5 river km).

1.3 Historical Review of Flooding

Records of flooding along the Bow River in the Cochrane area are practically non-existent. This can be attributed to the fact that the floodplain has remained undeveloped up until now, and thus, even though flooding of the low terraces must have occurred from time to time, it would not necessarily have been reported.

The following excerpts taken from The Cochrane Advocate indicate the river was in flood in June of 1915 and 1923:

> "An exceptionally bad rain storm visited Cochrane district commencing Friday afternoon and continuing till Saturday morning. The only damage reported is on low flat farms, where the drainage is poor. Our hillside and sloping fields are none the worse for the big drenching. The old Bow river carried an awful load up to noon on Saturday and overflowed the banks in many places."
>
> \- Cochrane Advocate, July 1, 1915

> "The Bow river and its tributaries were very high last week end and though the Bow has not caused any trouble in the immediate neighborhood of Cochrane, floods were reported along the Elbow and Little Red Deer rivers. The north approach to the Cochrane bridge would probably have caved in had not the bridge gang been on hand when the flood water came down. Heavy timbers and piles were used as supports and in spite of the extremely high water, the traffic across the bridge was not hindered."
>
> \- Cochrane Advocate, June 7, 1923

From Water Survey of Canada (WSC) discharge records, it is known that the 1915 and 1923 floods had peak discharges (at Calgary) of 1127 cubic metres per second (m^3/s) and 841 m^3/s, respectively. Discharges greater than the 1915 flood are known to have occurred in 1879 (2265 m^3/s Estimated), 1897 (2265 m^3/s), 1902 (1558 m^3/s), 1929 (1322 m^3/s) and 1932 (1518 m^3/s), however, there is no record of flood damages occurring in the study area.

Winter flooding of some low terraces along the Bow River has occurred on a relatively frequent basis following the installation of the Ghost Dam and Power Plant in the 1940's and the construction of the Bearspaw Reservoir in 1954. The flooding is caused by heavy ice pack accumulations which build upstream from the Bearspaw Reservoir. Depending on the prevailing climatic conditions and the mode of operation of the Ghost Power Plant, it is possible for ice pack levels in the Cochrane reach to equal or exceed the estimated level of historic summer flooding. The most severe incident appears to have occurred in February, 1973, when a short-term loss in thermal generating capacity necessitated an increase in the Ghost Plant output at a time when the ice pack accumulation was building through the Cochrane reach. TransAlta Utilities Corporation's records show that the ice pack water levels on this occasion reached a stage of approximately 4.5 metres (m) above normal summer levels. This is high enough to cause flooding of low-lying areas bordering the river.

Except for some sketchy reports of winter flooding on Bighill Creek near the Cochrane Ranch Historic site, there is no record of past flooding on either Jumpingpound or Bighill Creeks within the study area. Winter flooding in the vicinity of the Cochrane Ranch Historic Site,

located just upstream of Highway 1A, is believed to be caused by ice dams (aufice) which form in the spring fed creek, particularly in years with sudden and frequent temperature changes.

2.0 RIVER REGIME

2.1 Physiographic Setting

The headwaters of the Bow River are located in the Rocky Mountain Range north of Lake Louise. From this point, the river flows generally in a southeasterly direction through Banff National Park and into the foothills region east of Canmore. The river enters the study area (Figure 1) just west of Cochrane and flows southeasterly for approximately 27 km before leaving the study area below the Bearspaw Dam. The Bearspaw Reservoir has permanently flooded approximately 7 km of river reach at the eastern end of the study area.

Jumpingpound Creek has its headwaters in the Rocky Mountain Forest Reserve west of Bragg Creek. It flows generally northwards, entering the study area just south of Cochrane.

The headwaters of Bighill Creek are located in the foothills northeast of Cochrane. The creek flows generally southwards, entering the study area just north of the Cochrane town limits.

2.2 Channel Morphology and Valley Features

2.2.1 Bow River

The Bow River in the study reach flows in a stream cut valley situated within a wider post glacial valley[1]*. One or more fragmentary terrace levels exist in many locations. The top width of the valley varies from about 2 km to 4 km. The surrounding terrain is predominantly open range foothills which have been partially cultivated.

---

* Numbers in parenthesis refer to numbered references cited in the list of References

The channel pattern is sinuous with occasional islands, side and mid-channel bars. The channel is partially entrenched and frequently confined by high banks or steep valley walls. With respect to lateral activity, the channel can best be described as stable to only slightly unstable. Channel banks are mostly alluvial sand and gravel and the bed material is predominately gravel (D_{50} = 40 millimetres (mm) approximately).

2.2.2 Jumpingpound Creek

Jumpingpound Creek in the study reach is situated in a narrow stream cut valley having one fragmentary terrace level corresponding to the valley flat. The channel pattern is irregular with occasional islands, side bar and point bar formations.

The channel appears to be latterally stable, is frequently confined by steep valley walls and exhibits a pool and riffle sequence. The bed consists of gravels, cobbles and occasional boulders, whereas the channel banks are predominately alluvial gravels.

2.2.3 Bighill Creek

Bighill Creek flows in a narrow, steep-sloping ravine which leads onto the Bow River valley floor (secondary terrace level) at Cochrane. The channel pattern is irregular with a prominent pool and riffle sequence.

In the upper portion of the reach the channel banks and adjacent floodplain are heavily treed, however, where the creek flows through the Town of Cochrane the surrounding vegetation changes to mainly grasses. The channel bed consists of gravels and cobbles, and its banks are predominately alluvial gravels. There is no evidence of latteral instability.

2.3 River Surveys

A total of 108 cross sections were surveyed for this study, including 60 on the Bow River, 21 on Jumpingpound Creek and 27 on Bighill Creek. Most of the surveys were completed during the winter of 1982, however, the river portion of the Bow River cross sections, and some of the Bighill Creek cross sections, were completed the following summer. The survey was carried out by Alberta Environment Survey Branch personnel from Red Deer.

The locations of the surveyed cross sections are shown on the flood risk maps (Figure 7). Several representative cross sections are presented in Appendix A.

2.4 Hydraulic Characteristics

The computed average hydraulic characteristics for each river reach are presented in Tables 2.1 to 2.3 for various discharges.

2.5 Winter Ice Regime - Bow River

2.5.1 Impact of Hydro-Electric Power Projects

The winter ice regime on the Bow River has been greatly influenced by the development of hydro-electric power dams which have altered the natural ice formation processes in the river. The two plants which have a direct impact on the study reach are the Ghost Dam Power Station located approximately 19 km upstream of Cochrane, and the Bearspaw Dam located just outside Calgary's western city limits at the downstream end of the study reach.

TABLE 2.1

REACH AVERAGED
Hydraulic Characteristics - Bow River

Reach	$Q^{(1)}$	A	W	$D^{(3)}$	$V^{(4)}$	$S^{(5)}$	$Q^{(2)}$	A	W	$D^{(3)}$	$V^{(4)}$	$S^{(5)}$
CPR - Jumpingpound (cross section 59 - 51)	406	167	113	1.5	2.7	0.0022	990	313	131	2.4	3.6	0.0022
Jumpingpound - River Ave (cross section 50 - 36)	422	206	118	1.8	2.3	0.0022	1180	404	155	2.6	3.5	0.0022
River Ave - Glenbow (cross section 35 - 16)	422	210	126	1.7	2.2	0.0019	1180	404	152	2.7	3.3	0.0019
Glenbow - Bearspaw (cross section 15 - 1)	422	200	114	1.8	2.2	0.0017	1180	376	167	2.2	3.4	0.0017

(1) 1981 Peak Flow Estimate (m^3/s)

(2) 1:20 Year Flood Estimate (m^3/s)

(3) D = A/W where A = channel cross sectional area (m^2)
W = water surface width (m)
D = mean depth (m)

(4) V = mean channel velocity (m/s)

(5) S = Average water surface slope

TABLE 2.2

REACH AVERAGED
Hydraulic Characteristics - Jumpingpound Creek

Reach	Q(1)	A	W	D(3)	V(4)	S(5)	Q(2)	A	W	D(3)	V(4)	S(5)
Upper Reach (cross section 21 - 10	85	41	39	1.1	2.1	0.0064	190	68	42	1.6	2.8	0.0064
Lower Reach (cross section 9 - 1)	85	43	33	1.3	1.9	0.0046	190	67	36	1.9	2.6	0.0046

(1) 1:5 Year Flood Estimate (m^3/s)

(2) 1:20 Year Flood Estimate (m^3/s)

(3) D = A/W where A = channel cross sectional area (m^2)
W = water surface width (m)
D = mean depth (m)

(4) V = mean channel velocity (m/s)

(5) S = Average water surface slope

TABLE 2.3

REACH AVERAGED
Hydraulic Characteristics - Bighill Creek

Reach	Q(1)	A	W	D(3)	V(4)	S(5)	Q(2)	A	W	D(3)	V(4)	S(5)
Upstream of Hwy. 1A (cross section 1 - 9)	5	5.3	10.7	0.5	1.0	0.0077	21	12.9	13.1	1.0	1.6	0.0077
Hwy. 1A - Glenpatric Rd (cross section 10.1 - 18)	5	5.4	8.2	0.7	1.3	0.0064	21	14.2	12.8	1.1	1.6	0.0064
Glenpatric Rd - Bow River (cross section 19.1 - 27)	5	6.8	20.8	0.3	0.8	0.0100	21	19.0	29.0	0.7	1.6	0.0100

(1) 1:5 Year Flood Estimate (m^3/s)

(2) 1:100 Year Flood Estimate (m^3/s)

(3) D = A/W where A = channel cross sectional area (m^2)
W = water surface width (m)
D = mean depth (m)

(4) V = mean channel velocity (m/s)

(5) S = Average water surface slope

Winter releases from the Ghost Reservoir result in the production of large quantities of 'frazil ice'[1]. As a rule, the production of frazil ice will continue throughout the winter as long as air temperatures remain cold and as long as stretches of open water exist to allow supercooling of the flow. The warmer water stored in the large reservoir behind Ghost Dam virtually assures that the reach immediately below the dam remains open, and that large quantities of frazil ice can be produced.

The following is a simplified description of the freeze-up process normally occurring on the Bow River in the study reach:

1. A solid ice cover forms initially on the surface of the Bearspaw Reservoir, normally in late November or early December.
2. As atmospheric temperatures drop, frazil ice is produced in the open water reach between the Ghost Dam and the upper end of the Bearspaw Reservoir.
3. The frazil ice crystals gradually agglomerate to form flocs which then float to the surface, freezing and solidifying into frazil pans or 'pancake ice'. The pans are then carried downstream with the flow, reaching larger and larger proportions.
4. Once the floating pans reach the solid ice cover at the head of the Bearspaw Reservoir, the ice pack begins to build, gradually progressing up-river.
5. The distance the ice pack advances upstream depends on the severity of the winter.

Observations made by TransAlta Utilities Ltd. have shown that the ice pack extends up-river, at least as far as Cochrane, in four years out of five.

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[1] Frazil ice is a term used to describe small discoid shaped ice crystals which are formed in supercooled turbulent water.

2.5.2 Freeze-up Jams

The most significant feature associated with the freeze-up process in the study reach is the frequent occurrence of ice jams. Freeze-up ice jams most often occur when the advancing ice pack shoves or consolidates to reach an equilibrium (stable) thickness[1]. When this happens, water levels upstream of the toe of the consolidation movement often rise dramatically in a very short period of time.

The channel pattern and sectional geometry are major factors contributing to the formation of freeze-up jams, thus jams often occur in the same location every year. One prominent ice jam location in the study reach is the 90° bend immediately downstream of the River Avenue Bridge[2] at Cochrane. This location seems to be the position of a consolidation movement whenever the ice pack advances to Cochrane. On the other hand, the formation of ice jams is extremely unpredictable and they can potentially occur anywhere in a river reach.

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[1] The mechanism of ice jam formation is relatively complex. Further elaboration on this subject is beyond the scope of this report.

[2] Also known as the 'Old Cochrane Bridge'.

3.0 HYDROLOGY

This section of the report deals with the analysis of recorded floods on the Bow River and its tributaries in the vicinity of Cochrane. The analysis was used to estimate the probability of future major floods. A brief summary of the main findings of the complete hydrological assessment, which can be found in Appendix B, is presented.

3.1 Flood Moderating Influences

The Bow River basin has undergone considerable change since the start of systematic streamflow records at Calgary in 1908. Land use changes, water diversions, and reservoir regulation could be causes of changes to flows on the Bow River system. These possible reasons for changes in the flood potential were examined, and it was concluded that the probability of future flood occurrences should be determined by inclusion of the total flood record.

3.1.1 Land Use Changes

The only significant land use change, in terms of the total drainage basin area, is the effect of a forest cover on runoff. A forest cover will intercept initial precipitation until the cover is saturated and will also decrease the intensity of the rainfall reaching the ground. Interception will also increase evapotranspiration losses and thus effectively reduce both snowmelt and rainfall runoff. Thus, it may be assumed that the existence of forest cover will decrease the peak runoff rate, and conversely, that a lack of forest cover will increase the peak runoff rate.

The forest cover may, however, be depleted or replenished at any time by man or nature, and should not be considered as a permanent change on the flood pattern. Thus, in a hydrologic flood frequency analysis the entire flood record should be used, regardless of forest cover influences.

3.1.2 Water Diversions

Consumptive water diversions on the Bow River system above the City of Calgary are limited to relatively minor licenced water supply systems for municipal, industrial, and domestic uses. The quantity of these diversions during the short duration of a flood wave travelling through the system will reduce the peak flow rate of the flood insignificantly.

The Bow River system above the City of Calgary also has two non-consumptive diversion schemes. These are the Smith-Dorrien Creek diversion and the Ghost River diversion. The Smith-Dorrien Creek diversion diverts water from a 36 square kilometre (km²) (14 square mile) area, which drains naturally into the Kananaskis Lakes, then into the Spray Reservoir system through the Mud Lake diversion canal. Recorded flows, at WSC station 05BF013 (Mud Lake Diversion Canal) from this diversion are less than 0.6% of recorded peak flows at Calgary, and would not influence a hydrologic flood frequency analysis. Storage reservoir influences will apply to water quantities diverted by the Smith-Dorrien Creek diversion.

The Ghost River diversion scheme diverts water from a 220 km² (85 square mile) area, in the headwaters of the Ghost River, into Lake Minnewanka. A comparison of recorded flows at WSC station 05BG003 (Ghost River Diversion to Lake Minnewanka) and 05BG002 (Ghost

River near Black Rock Mountain) immediately upstream of the diversion, shows that about 65% of the water is diverted into the Lake Minnewanka system. Storage reservoir influences will apply to water quantities influenced by the Ghost River diversion.

The Ghost River diversion dam normally diverts up to 7 m³/s (250 cubic feet per second (cfs)) into the diversion canal leading to Lake Minnewanka. When the Ghost River flow exceeds 34.0 m³/s (1200 cfs), the diverted flow rate approaches 11.3 m³/s (400 cfs). A reduction of 11.3 m³/s (400 cfs) for a major flood on the Ghost River represents less than 3% of the Ghost River flow. For example, the largest recorded peak flow at WSC station 05BG001 (Ghost River near Cochrane) on June 2, 1932 would be reduced to 382 m³/s (13,500 cfs) from the recorded 394 m³/s (13,900 cfs). Negligible flood moderating influences are assumed for major floods on the Ghost River due to the diversion into Lake Minnewanka.

3.1.3 Reservoir Regulation

The Ghost reservoir is the only reservoir located low enough in the Bow River drainage basin to control a significant portion (78%) of the area contributing runoff to floods at Cochrane. The Ghost reservoir only accounts for 12% of the total live storage on the Bow River. The remaining 88% of the live storage controls only 27% of the Bow River basin. Barrier reservoir accounts for only 3% of the total live storage. Thus, 85% of the total live storage in the Bow River basin controls 20% of the drainage area of the Bow River above Cochrane.

All of the reservoirs on the Bow River system are gradually filled through the spring and summer to ensure that sufficient water is conserved to support power generation and required flow through the

following winter. These reservoirs are not necessarily operated to provide storage for flood control purposes.

The large summer storms, which in combination with snowmelt runoff from the headwaters produce the severest floods on the Bow River, deposit the bulk of their precipitation east of the front range of the Rocky Mountains. The runoff from these storms mainly occurs below the reservoirs which have 85 percent of the live storage. Therefore, no major flood control over rainfall runoff should be expected in the Bow River basin above Cochrane. Minor flood control, depending on available storage, may be possible by storing inflow in the upstream reservoirs.

The influence of the Ghost Reservoir in moderating flood peaks was examined by recreating natural flood hydrographs for six years at the damsite. Storage changes in the Ghost reservoir were added to recorded flows below the dam to create the hydrographs. In three of the six years analysed, the regulated reservoir release exceeded the estimated natural daily maximum flow. The difference between the regulated and natural flows were negligible. It was concluded that the recorded flood series approximates the natural flood series for the downstream reaches of the Bow River.

In summary, storage reservoirs on the Bow River system have negligible influences in moderating floods on the system, and could not account for the significant statistical differences between the early record and later record. The entire flood record for the Bow River system above Calgary should therefore be used in the determination of flood frequency estimates when storage reservoir influences are considered.

3.2 Annual Flood Series

Two series of extremes are common to flood frequency analysis. The most widely used, extreme value series, is comprised of annual extremes. This series has a good theoretical basis for extrapolating the series beyond the range of observation. A criterion for the annual series is independence of events. The annual series of maximum instantaneous discharges for the Bow River and its tributaries can be considered independent. The low flow period during the winter excludes any possibility of one annual flood influencing another.

A second extreme value series is the partial duration series. This series is comprised of all events above a given base value. The lack of independence between associated events has limited the development of statistical theory for this series. The partial duration series tends to merge with the annual series at return periods greater than 1:10 years. As this study is concentrating on events greater than a 1:10 year return period, the annual series was used in the analysis.

WSC station 05BA001 - Bow River at Lake Louise, has recorded annual maximum daily discharges for the years 1911 to 1920, 1964 to 1971, and 1973 to 1982. For years where the maximum instantaneous discharge was not identified, estimates were computed from a least squares curve fit between maximum daily and maximum instantaneous discharge for years with both records. There are 14 years where both parameters are available. The total flood record includes 28 annual maximum flood events.

WSC station 05BB001 - Bow River at Banff has recorded annual maximum daily discharges for the years 1909 to 1982. For years where the maximum instantaneous discharge was not identified, estimates were computed from a least squares curve fit between maximum daily and

maximum instantaneous discharge for years with both records. There are 36 years where both parameters are available. The total flood record includes 74 annual maximum flood events.

WSC station 05BE004 - Bow River near Seebe has recorded annual maximum daily and maximum instantaneous discharges for the period 1923 to 1962 and 1979 to 1982. The total flood record includes 44 annual maximum flood events.

Flood frequency estimates for Bow River above Elbow River were determined for the historical period 1879 to 1980. The data set is comprised of annual maximum instantaneous flood peaks for the period 1908 to 1980 and estimates of the peak flow for the floods of 1879, 1897, and 1902. The flood series was recorded or estimated from the data gathered at hydrometric station number 05BH004 (Bow River at Calgary).

Flows were recorded on Jumpingpound Creek for a period of 30 years between 1908 and 1982. WSC station 05BH006 - Jumpingpound Creek near Jumpingpound operated from 1907 to 1919 and in 1933. WSC station 05BH009 - Jumpingpound Creek near the Mouth has been in operation since 1966. These records provide the data base for estimating flood frequencies for Jumpingpound Creek at the Confluence of the Bow River.

No streamflow measurements are available for Bighill Creek at Cochrane. Therefore, flood frequency estimates at this location were determined by analogy with recorded flow data at WSC station 05BH003 - Nose Creek at Calgary, which includes the years 1911 to 1919 and 1973 to 1982. The total flood record includes 19 annual maximum flood events.

3.3 Analysis of Flood Series

A detailed analysis of instantaneous discharge is provided for the Bow River and its tributaries within the study area. Recorded flows on these river systems form the basis of the analyses. Several statistical distributions were applied to the flood data to select a distribution which satisfies both a selection criterion and sound hydrologic theory. Inclusion of historic floods in the analysis provides more reliable estimates of future flood flows. Coincidence of flood peaks was examined and provided the basis for estimating flood frequencies on the Bow River and its tributaries in the vicinity of Cochrane.

3.3.1 Distribution Selection

Annual maximum instantaneous discharges are a series of random events for which the population distribution is unknown. However, to facilitate assigning flood probabilities, it is necessary to associate a frequency distribution with these events. The criterion that is used to select a statistical distribution is based on the expected probability of a given event being equalled or exceeded in the series of recorded events. The probability theory can be represented by Equation 3-1.

$$P_{nr} = p^n q^{r-n} \left(\frac{r!}{(r-n)!\, n!} \right) \qquad \text{(Equation 3-1)}$$

Where P_{nr} = the probability of a particular event being equalled or exceeded n times in a sample of r events.

p = 1/t where t is the return period of the event

q = 1 - p

Flood frequency estimates for the Bow River at Lake Louise, at Banff, near Seebe, and at Calgary were determined from seven commonly used statistical distributions. The distributions are Gumbel I, log-Gumbel I, normal, log-normal, 3-parameter log normal, Pearson III and log-Pearson III. Details on these distributions are found in several publications (Chow[2]; Grey[3]; Kite[4]) and are not presented in this report. The majority of the distribution parameters are computed using the maximum likelihood theory. The exception is the Pearson III distribution, where sample skewness exceeds the maximum of 2 required for a maximum likelihood solution. In this case, the method of moments is used to determine distribution parameters. The log-Pearson III analysis is presented for both methods.

The Pearson III frequency distribution, based on the method of moments, was the only distribution accepted by the selection criterion for the Bow River data sets. This distribution offers considerable flexibility in that the skewness of the distribution, within the theoretical limits of skewness, is determined from the data sample. This distribution also has a lower boundary which ensures that negative floods for lower return periods are not computed for positively skewed data sets common for almost all hydrologic events. The decision was, therefore, to use the Pearson III distribution in assigning flood probabilities.

3.3.2 Historical Floods

The 1968 study on the "Floodplain of Bow River in the City of Calgary"[5] reported that the floods of 1879 and 1897 were the largest known floods on the Bow River at Calgary. Newspaper reports and local

residents indicated that the flood of 1879 was as severe as the flood of 1897. Thus, these two flood events were considered equal in magnitude.

The historical floods of 1897 and 1902 were determined from recorded high water marks taken at the existing Langevin bridge gauging site, located above the confluence of the Elbow River. The peak flows were estimated from the extrapolation of the existing stage-discharge relationship measured at the bridge site. The historical flood estimates (documented floods of greater magnitude than the largest flood in the continuous streamflow records) for the Bow River above Elbow River are 2270 m^3/s (80,000 cfs) for the 1879 and 1897 floods and 1560 m^3/s (55,000) for the 1902 flood.

Analytical techniques used to compute a historically adjusted Pearson Type III frequency curve are presented in "Guidelines for Determining Flood Flow Frequency" by the United States Water Resources Council[6]. Appendix B provides the methodology of these procedures.

3.3.3 Coincidence of Flood Peaks

A study of recorded streamflow on the Bow River and its tributaries shows that coincidence of flooding is a common occurrence. Storm patterns over the Bow River basin confirm this phenomenon. Large floods on the tributaries of the Bow River are caused by storms which, by virtue of their size, also produce flooding on the Bow River. Therefore, for floodplain delineation purposes, coincidence of flood peaks is assumed for Jumpingpound Creek and Bighill Creek at their confluences with the Bow River.

3.4 Summary of Results

Current flood frequency estimates for the Bow River and its tributaries in the vicinity of Cochrane were required for delineating flood risk boundaries. A thorough analysis of applicable data indicated that the recorded flood series approximates the natural flood series for the Bow River system. The Pearson Type III frequency distribution provided the best flood estimates for the recorded flood data. The inclusion of historical flood data in the analysis increased the reliability of predicted future flood magnitudes.

Flood moderating influences on the Bow River system were examined in detail. In general, flood moderating influences on the system, to date, were found to be negligible.

The 1:100 year return period flood peaks for the Bow River above the confluence of Jumpingpound Creek and the Bow River at Calgary are estimated to be 1590 m^3/s and 1960 m^3/s, respectively. The 1:100 year return period flood peaks for Jumpingpound Creek and Bighill Creek at their confluences with the Bow River are estimated to be 323 m^3/s and 20.8 m^3/s, respectively. Coincidence of flood peaks is assumed for floodplain delineation studies.

Table 3.1 lists the flood frequency estimates for the Bow River above Jumpingpound Creek and at Calgary. Table 3.2 lists the estimated flood frequencies for Jumpingpound Creek and Bighill Creek at the confluence of the Bow River.

TABLE 3.1

Flood Frequency Estimates
Bow River near Cochrane

Return Period (years)	Annual Maximum Instantaneous Discharge (m^3/s)	
	Bow River above Jumpingpound Creek	Bow River at Calgary
100	1590	1960
50	1340	1620
20	990	1180
10	780	882
5	580	613
2	351	351

TABLE 3.2

Flood Frequency Estimates
Jumpingpound Creek and Bighill Creek

Return Period (years)	Annual Maximum Instantaneous Discharge (m^3/s)	
	Jumpingpound Creek at the Confluence of the Bow River	Bighill Creek at the at the Confluence of the Bow River
100	323	20.8
50	265	16.9
20	190	11.9
10	135	8.34
5	84.5	5.02
2	27.3	1.36

4.0 CALCULATION OF FLOOD LEVELS - OPEN WATER CONDITIONS

4.1 Methodology

4.1.1 HEC-2 Model

The water surface profiles for the study reach were calculated using a computer program (HEC-2) developed by the U.S. Army Corps of Engineers' Hydrologic Engineering Centre[7]. This program is designed to calculate water surface profiles for steady gradually varied flow in natural channels, and can handle both subcritical and supercritical flow. The effect of various structures such as bridges, culverts and weirs can be modelled by the program.

The analytic technique used in the HEC-2 program is based upon the solution of the one dimensional energy equation (Bernoulli) with energy losses due to friction calculated using Manning's equation. The Standard Step Method of profile calculation is used in the computation. The geometric data for the HEC-2 model is constructed from the surveyed river cross sections and the distances between cross sections (reach lengths) are specified.

The basic assumptions and limitations of the HEC-2 model are:

1. The channel bed and banks are fixed (rigid) as compared to the actual river which is subject to extensive scour and deposition during floods.
2. The discharge is assumed to be steady.
3. Uniform hydrostatic pressure distribution is assumed across the channel sections resulting in a level water surface from one bank to the other including sharp bends.

4. Velocity components are assumed to be in the direction of flow, thereby total energy head is considered the same at all points across the section. And,

5. The river channel slope is assumed small (less than 1 in 10).

4.1.2 Data Assembly

The cross sectional survey data base for the Bow River, Jumpingpound Creek and Bighill Creek were assembled and input into HEC-2 format. Cross sections were plotted from survey co-ordinates onto 1:5000 scale orthophoto maps. Reach distances between cross sections were then scaled directly from the orthophoto maps. Distances between sections for the main channel were taken along the centre line of the river. The overbank distances were taken along a line estimated to trace the approximate centroid locations of the overbank flow area (except for Bighill Creek where the centre line distance was used due to the narrow width of the effective flow section).

To satisfy criteria 4 (Section 4.1.1), surveyed cross sections which were skewed to the flow were adjusted by a correction factor. Only those cross sections skewed more than 15° were adjusted since the error was considered negligible for lesser skews.

4.1.3 Starting Water Surface Elevation

The water surface calculations for the Bow River were started at the upper end of the Bearspaw Reservoir. The starting water surface elevation was set at Elevation 1090.6 m corresponding to the maximum reservoir operating level[1] during passage of a 1% (1:100 year) flood.

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[1] Elevation provided by TransAlta Utilities Corporation

The starting water surface elevation on Jumpingpound Creek (at the mouth) was set at Elevation 1126.5 m corresponding to the computed 1% (1:100 year) flood level of the Bow River at the creek confluence. In other words, coincident peaking was assumed (see Section 3.3.3). Similarly, the starting water surface elevation for Bighill Creek (at the mouth) was taken to be Elevation 1122.0 m.

4.1.4 Manning's Roughness (Overbanks)

The selection of overbank and upper bank roughness coefficients was based on a widely used table of values taken from Chow[8]. This table has been reproduced, in part, as Table 4.1. Recent aerial photographs, as well as field survey notes were used in assigning the roughness coefficients in the manner described below.

For the Bow River portion of the study, Manning's roughness coefficients were input into the HEC-2 model using a feature of the program which permits the variation of the roughness values with horizontal distance across each cross section, as well as along the river between cross sections. This makes it possible to model the variation in roughness between the overbanks, the upper bank regions (above the normal water line), and the channel bottom.

For Jumpingpound Creek and Bighill Creek, a single roughness value was assigned for each of the left and right overbanks. This simpler method was used for the smaller streams as it was found to be far more practical to use a 'combined roughness' value for the main channel and upper banks, and a reach-averaged roughness value for each of the overbanks. A sensitivity analysis was carried out to confirm that this simplification did not compromise the accuracy of the computed water surface profiles.

TABLE 4.1

Range of Manning's Roughness (n) Values used for Overbank Areas

Overbank Type	Range in 'n'
Pasture, short to long grass	0.03 to 0.04
Brush and trees, scattered to medium density	0.05 to 0.07
Brush and trees, medium to heavy density	0.07 to 0.16

4.2 Model Calibration

4.2.1 Bow River

To obtain reliable results using a mathematical model such as HEC-2, the model should be calibrated so that it will reproduce recorded water surface elevations, for an actual documented flood, with a reasonable degree of accuracy. The calibration procedure basically involves adjusting the hydraulic roughness coefficients (Manning's n) in the model until computed water levels match the recorded highwater marks for the documented flood. In this case, only the channel 'n' values were adjusted.

The major historic floods on the Bow River occurred in the latter part of the last century and the early part of the present century (see Section 1.3). Unfortunately, no highwater mark data is available for these floods within the study reach. The only existing highwater mark data (Appendix C) was obtained along a 5 km reach near the Town of Cochrane during the June 1981 flood. This was a modest flood event having an estimated peak instantaneous discharge of 422 m^3/s (at Cochrane) and a return frequency which is only slightly greater than the

1:2 year flood. A channel roughness value of 0.03 produced computed water surface profiles which best matched the 1981 highwater mark surveys.

In order to obtain a better estimate of channel bed roughness at the 1% (1:100 year) flood discharge, the model was calibrated further using a stage-discharge rating curve (Figure 2) for the 1916 flood. The rating curve was constructed from stage-discharge measurements taken at a temporary gauging station located at the 'Old Cochrane Bridge' crossing[1]. By calibrating the model against the range of discharges covered by the rating curve a relationship between discharge and Manning's n was determined (Figure 3). It was assumed that the roughness values shown in Figure 3 would be fairly representative of the channel roughness for the entire study reach. This is believed to be a reasonable assumption, since the channel bed material, average sectional geometry and plan form, all factors which influence the hydraulic roughness, do not change significantly within the study reach.

From Figure 3, a Manning's roughness of 0.026 was selected for the study, and was used to compute the water surface profiles for the 1% flood shown on Figure 4. It should be noted that the findings of this study are consistent with the Calgary Floodplain Study[9] which also adopted a Manning's roughness of 0.026 for the reach immediately downstream of Bearspaw Dam.

To further substantiate the selection of Manning's roughness for this study, a sensitivity analysis was carried out to determine how

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[1] The original bridge was later replaced by the present structure (River Avenue Bridge).

sensitive the water surface profiles were to changes in channel bed roughness. The sensitivity test was limited to the range of n = 0.025 to n = 0.028, which was felt to be the most reasonable upper and lower values for the study reach. The results showed that by increasing roughness from n = 0.025 to n = 0.028 the water surface profile increased an average of 0.15 m (6"). Thus for a change in roughness of 12%, the average flow depth increase of 0.15 m amounts to about 3.0% for a depth of 5.0 m. These results indicate that the Bow River model is not overly sensitive to changes in bed roughness (n_{ch}) values, thus the selected roughness value can be used with confidence.

4.2.2 Jumpingpound Creek

Unlike the Bow River, no highwater mark data is available for Jumpingpound Creek within the study reach. An established WSC gauging station (No. 05BH009) is located about 4.2 km upstream of the study limits, however, due to the distance between the gauge site and the study reach, it was felt that any stage-discharge relationship which exists for the gauge site could not be reliably transferred downstream to the study reach. As a consequence, the HEC-2 model for Jumpingpound Creek could not be calibrated.

In order to compute an approximate 1% (1:100 year) water surface profile on Jumpingpound Creek a probable range of Manning's roughness values (n = 0.03 to n = 0.04) for this type of stream was selected based on judgement and experience with similar creeks. A sensitivity analysis was undertaken by adjusting the channel roughness coefficients in the model over the above range of values. As mentioned in Section 4.1.4, the roughness values for Jumpingpound Creek were input into the

model so that the channel roughness takes into account the composite bed and bank roughness.

The results of the sensitivity analysis showed that by increasing roughness from n = 0.03 to n = 0.04, the water surface profile increased an average of 0.25 m (10"). A Manning's roughness of 0.04, which is the upper limit of the probable range of values, was selected for the study. This represented a conservative approach to the determination of the flood level profile. The computed 1% (1:100 year) flood levels are presented in Figure 5.

4.2.3 Bighill Creek

Due to the absence of highwater mark data on Bighill Creek, a similar procedure was used to estimate the 1% (1:100 year) water surface profiles as was used for Jumpingpound Creek (Section 4.2.2). The probable range of Manning's roughness values for Bighill Creek was taken to be n = 0.05 to n = 0.07, again based upon experience. A sensitivity analysis was undertaken by adjusting the channel roughness coefficients in the model over the above range of values. The results of the sensitivity analysis showed that by increasing roughness from n = 0.05 to n = 0.07, the water surface profile increased an average of 0.20 m (8"). Again, to be conservative, a Manning's roughness of 0.07, which is the upper limit of the probable range of values, was selected for the study. The computed 1% (1:100 year) flood levels are presented in Figure 6.

5.0 CALCULATION OF FLOOD LEVELS - WINTER ICE CONDITIONS

5.1 Bow River

5.1.1 Available Historical Data on Winter Ice Pack Levels

Valuable information on winter flow levels and the extent of ice pack buildup on the Bow River in the study reach has been documented by TransAlta Utilities Corporation (formerly Calgary Power Ltd.). Of particular use to this study was several years of observed maximum winter flow levels at the River Avenue Bridge (Old Cochrane Bridge) during the period between 1947-48 and 1979-80. This data is summarized in Appendix D.

5.1.2 1981-82 Ice Pack Survey

The maximum stage of the ice pack buildup in a 7.0 km reach near the Town of Cochrane was surveyed and documented by Alberta Environment (Appendix D) during the winter of 1981-82. Even though the maximum stage of the 1981-82 ice pack at the River Avenue Bridge (Elevation 1118.17 m) proved to be 1.19 m below the maximum recorded winter stage for the period of record (Elevation 1119.36 m in February, 1973), it is equal to the stage of the computed 1:100 year open water level. The maximum ice pack stage at the other 7 sites surveyed that year are also within ±0.5 m of the 1:100 year open water level.

5.1.3 Frequency Analysis of Winter Stages at the River Avenue Bridge

Two commonly used statistical distributions (Log-Normal and Pearson III) were used to compute winter stage frequency estimates at the River

Avenue Bridge. Available data from the period of record, 1947-48 to 1982-83 were used in the analysis (Appendix D). The data sample is from the period following the installation of the Ghost Power Plant, and was assumed to be a representative sample of random homogeneous events.

The Pearson III distribution was selected for this study as it best fit the plotted data points in the upper range of the frequency curve (Appendix D). The computed frequency distribution is given in Table 5.1.

TABLE 5.1

Frequency Distribution of Maximum Annual Winter Stages* at the River Avenue Bridge

Return Interval (years)	Stage (m)
100	1119.88
50	1119.68
20	1119.39
10	1119.14
5	1118.84
2	1118.32

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* Ice Flood Level

5.1.4 Approximate 1:100 Year Ice Flood Levels

Unlike open channel flow, or even flow under a stable ice cover, there is no reliable method to compute winter backwater levels over a large reach of river where freeze-up jams and ice pack consolidation movements are a common occurrence. Levels at a specific site can be predicted by statistical methods only if sufficient data on past winter stages is available, such as at the River Avenue Bridge (Section 5.1.3).

Theoretical methods, based upon the physical mechanics of ice jams can be attempted, but these are also site specific and are not always reliable owing to the numerous assumptions required in the computational procedure.

The method adopted in this study to determine an approximate 1% (1:100 year) ice flood profile on the Bow River is based on the assumption that the stage-frequency distribution determined for the River Avenue Bridge site would be valid for the study reach in general. This is a major assumption which can only be expected to produce approximate results, however, it appears to be the most reasonable approach to the problem at the present time.

The ice flood profile presented in Figure 4 was established by transferring the estimated 1:100 year winter stage level at the River Avenue Bridge (Elevation 1119.88 m) upstream and downstream by the reach averaged river slope[1]. To check the validity of this method, the resulting ice flood profile was compared to the actual surveyed ice profile obtained in January 1982. The slopes of the 'computed' and 'observed' profiles were found to be approximately equal (within ±0.02%). It was therefore concluded that the ice flood profile presented on Figure 4 represents a reasonable approximation of the 1:100 year ice induced flood on the Bow River.

The resultant ice flood profile determined by the above method varies from about 1.0 m to 2.0 m higher than the computed 1% (1:100

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[1] The 'reach averaged' river slope was determined by calculating the average slope (taken over a reach of several kilometres) of the computed 1:100 year water surface profile (Figure 4).

year) open water flood levels (Figure 4), which is not an unusual occurrence (see for example Gerard and Karpuk[10]). This indicates that the potential for the ice flooding in the study reach is significantly greater than for open water (summer) flooding.

5.2 Jumpingpound Creek and Bighill Creek

Insufficient data on winter stages were available for either Jumpingpound Creek or Bighill Creek to carry out an analysis similar to that on the Bow River.

In the case of Bighill Creek, high ice levels obtained in 1982, at the same time as the cross section surveys, are plotted on Figure 6 along with the computed 1:100 year open water profile. The ice buildups which are caused by aufice formation in the spring-fed creek are equal to, or higher than, the computed 1:100 year open water levels in several locations, especially in the vicinity of culverts or bridges. These limited data indicate that the potential for ice related flooding problems, in some reaches of Bighill Creek, is at least as great as for open water (summer) flooding.

On Jumpingpound Creek the major area of concern, with respect to ice flooding, is in the extreme lower portion of the study reach just upstream from its confluence with the Bow River. In this area winter levels are influenced by ice pack levels on the Bow River. The approximate 1:100 year ice flood level (Bow River) is shown on Figure 5 to extend up the creek approximately 450 m upstream from the confluence.

There is also a potential for ice jams to occur on Jumpingpound Creek during the spring breakup period. This would be particularly true in years when the ice pack on the Bow River has built past the

confluence and is still intact when the ice run on Jumpingpound Creek reaches the mouth. If an ice jam were to form during even a moderate spring runoff on Jumpingpound Creek, abnormally high backwater levels would likely occur. Unfortunately, however, the magnitude and frequency of such an event cannot be determined in the absence of actual field observations. Therefore, no attempt has been made to estimate 1 in 100 year ice flood levels on Jumpingpound Creek.

6.0 FLOOD RISK MAPPING

6.1 Base Mapping

The base maps used to delineate the flood risk areas for this study are 1:5000 scale orthophoto maps with a 1.0 m contour interval. Existing map coverage included only the immediate Cochrane vicinity, therefore, additional mapping, to include the reaches immediately above Cochrane and between Cochrane and the Bearspaw Dam, had to be prepared specially for this study. The former was produced by the Alberta Bureau of Surveying and Mapping from aerial photography flown in May, 1981 and October, 1983. The latter was produced by Terrain Aerial Surveys Ltd., from aerial photography flown in July, 1983.

6.2 Ice Hazard Zone/Flood Risk Zone

The flood levels calculated in Sections 4 and 5 were plotted on the orthophoto base mapping (Section 6.1). Wherever possible, both an ice hazard zone (winter flooding) and a flood risk zone (open water flooding) have been delineated on the base maps to produce the flood risk maps for this study. However, in areas where only the 1% (1:100 year) open water flood profile has been computed, or where the two flood zones coincide, only one line is delineated.

The intent of presenting both the ice hazard zone and flood risk zone is to provide as much information as possible to enable the regulatory agencies, planners, and developers to make rational decisions with respect to floodplain management and development. Unlike most jurisdictions, where the 1% (1:100 year) open water flood is the single designated flood for regulating land development, it is critical that

the potential for ice related flooding also be recognized in the regulation of floodplain activity within this study reach.

6.3 Freeboard and Setbacks

It is not the purpose of this study to determine freeboard or setback requirements for development. These should be assessed on a site specific basis. For example, a certain amount of encroachment into either the ice hazard zone or the flood risk zone may be acceptable in some locations, but should not be permitted in others. Likewise, freeboard requirements above the computed water surface profiles (Figures 4, 5 and 6) may vary depending on site specific conditions. This is especially true in determining freeboard requirements for ice flooding, which can be greatly influenced by the channel geometry and morphology.

6.4 Flood Risk Maps

The flood risk maps for the Bow River, Jumpingpound Creek and Bighill Creek are shown in Figure 7, Sheets 2 to 12. An index plan for these maps is provided in Figure 7, Sheet 1.

The following sections are intended to supplement the flood risk maps by highlighting some of the relevant information with respect to flood prone areas.

6.4.1 Bow River (Figure 7, Sheets 2 to 10)

Typically, most of the first level terraces bordering the river channel are within the ice hazard zone. These terraces are found on both sides of the river along the entire study reach and are presently

undeveloped (mainly open range or pasture), except in the immediate Cochrane area where the following structures/facilities are affected:

Farm Buildings	SW 4-26-4-W5	(Sheet 2, Cross Section 51)
Girl Guide Camp Facility	W½ 34-25-4-W5	(Sheet 3, Cross Section 42)
Buildings	E½ 35-25-4-W5	(Sheet 3, Cross Section 31)

The amount of land within the 1:100 year flood risk zone is considerably less than that affected by the ice hazard. It generally amounts to a relatively narrow strip along the edge of the channel banks.

6.4.2 Jumpingpound Creek (Figure 7, Sheet 11)

In general, most of what could be termed the valley flat bordering Jumpingpound Creek is within the 1:100 year flood risk zone. The land is undeveloped (partly forested) at present, therefore no buildings or facilities are affected.

The low-lying area (active floodplain) between the local bridge crossing in SE 4-26-4-W5 and the Bow River confluence is within the ice hazard zone determined for the Bow River. There has been no attempt, however, to delineate an ice hazard zone upstream of the bridge crossing in SE 4-26-4-W5. It is not known whether potential ice jam induced flooding would exceed the estimated 1:100 year open water flood levels in this reach of Jumpingpound Creek.

6.4.3 Bighill Creek (Figure 7, Sheet 12)

On Bighill Creek the ice hazard zone and the 1:100 year flood risk zone are shown to coincide. This is an approximation based on one year's observation (1982) of ice buildup in Bighill Creek.

The flood risk zone does not affect any of the existing built up areas of Cochrane between Highway 1A in the north and Griffin Road in the south. The narrow green belt which was maintained when development occurred in this area is adequate and should remain undisturbed except for recreational use.

North of Highway 1A, a portion of the Old Cochrane Ranch Historical Site (primarily picnic areas) lies within the flood risk zone. Upstream of this point most of the narrow valley flat bordering Bighill Creek is also flood prone.

REFERENCES

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3. Grey, D.M., "Handbook on the Principles of Hydrology", Water Information Center Inc., Port Washington, New York, 1970.

4. Kite, G.W., "Frequency and Risk Analysis in Hydrology", Inland Waters Directorate, Water Resources Branch, Environment Canada, Ottawa, 1976.

5. Montreal Engineering Company Ltd., "Floodplain of the Bow River in the City of Calgary", Calgary, Alberta, 1968.

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7. U.S. Army Corps of Engineers, "HEC-2 Water Surface Profile Users Manual", Hydrologic Engineering Centre, Davis, California, January, 1981.

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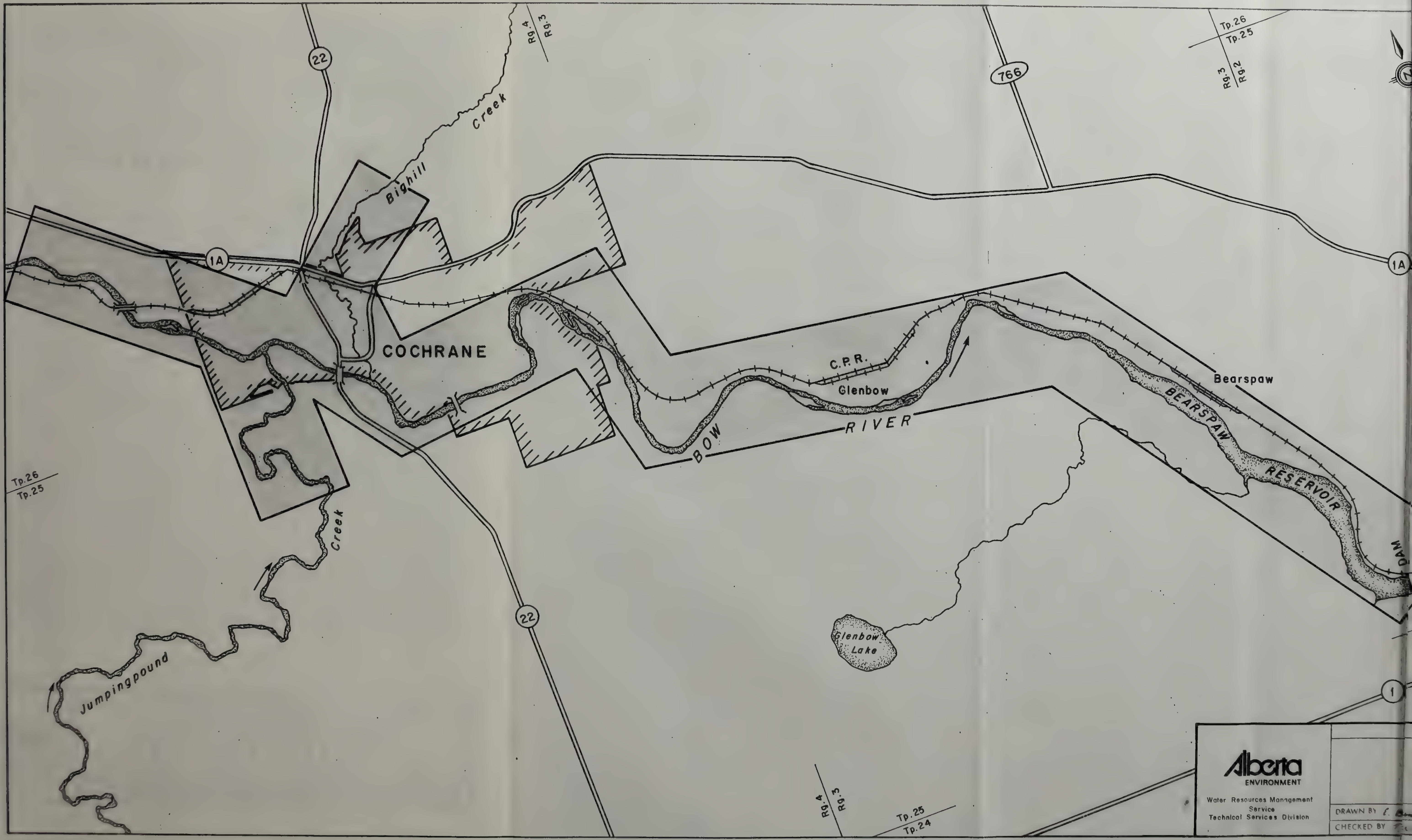
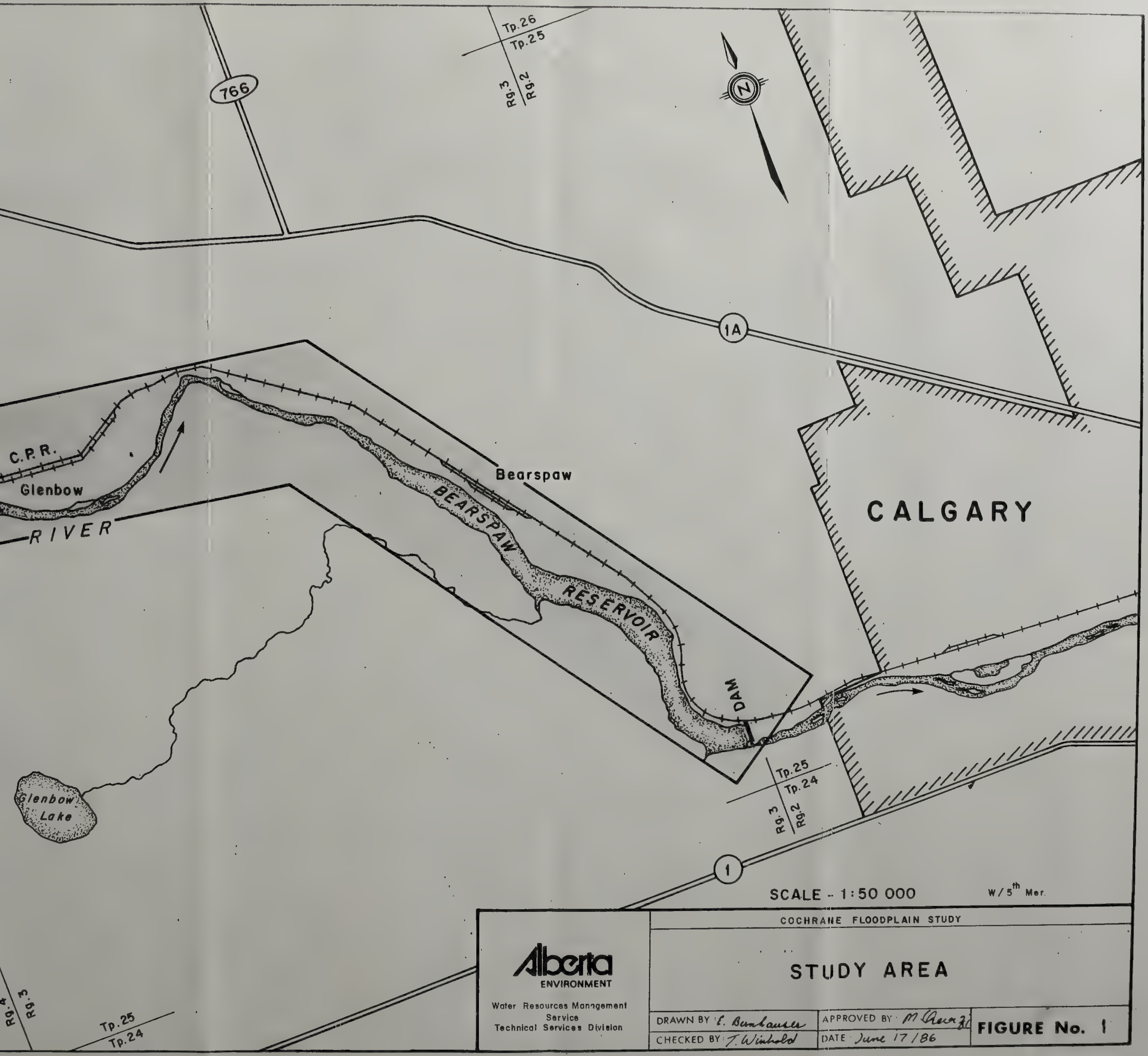
9. Quazi et al, "City of Calgary Floodplain Study", Alberta Environment, Edmonton, Alberta, April 1983.

10. Gerard and Karpuk, "Probability Analysis of Historical Flood Data", ASCE, Journal of Hydraulics Division, V.105, No. 1449, September 1979.

FIGURES


Rg.4
Rg.3
22
Creek
Bighill
766
Tp.26
Tp.25
Rg.3
Rg.2
1A
COCHRANE
C.P.R.
Glenbow
Bearspaw
BEARSPAW
RESERVOIR
DAM
BOW
RIVER
Tp.26
Tp.25
Creek
Jumpingpound
22
Glenbow
Lake
1
Rg.4
Rg.3
Tp.25
Tp.24
Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division
DRAWN BY
CHECKED BY



Alberta ENVIRONMENT

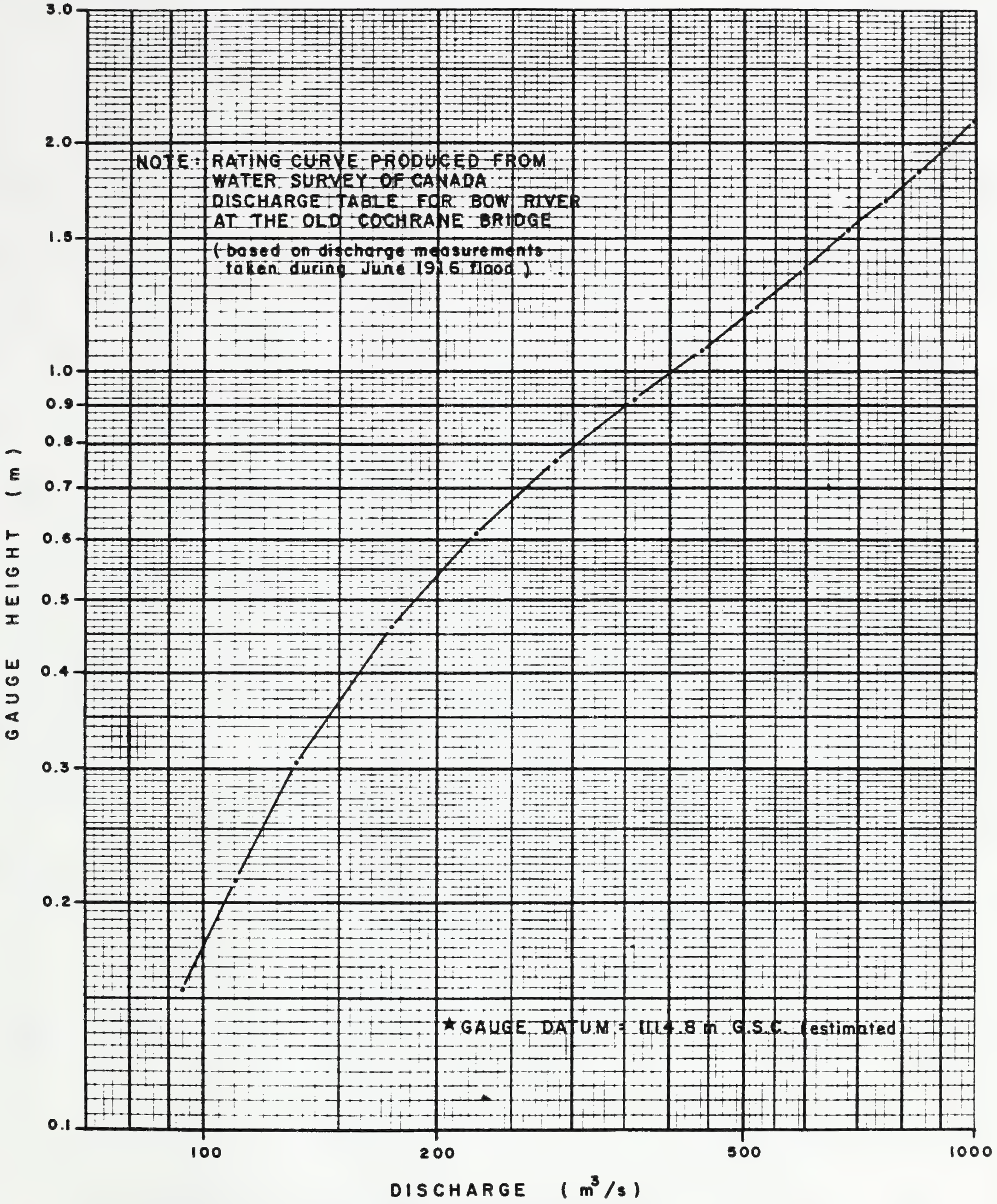
Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

STUDY AREA

DRAWN BY: E. Bunbauer
CHECKED BY: T. Winhold
APPROVED BY: M Chen
DATE: June 17/86

FIGURE No. 1



NOTE: RATING CURVE PRODUCED FROM WATER SURVEY OF CANADA DISCHARGE TABLE FOR BOW RIVER AT THE OLD COCHRANE BRIDGE

(based on discharge measurements taken during June 1916 flood)

★ GAUGE DATUM = 1114.8 m G.S.C. (estimated)

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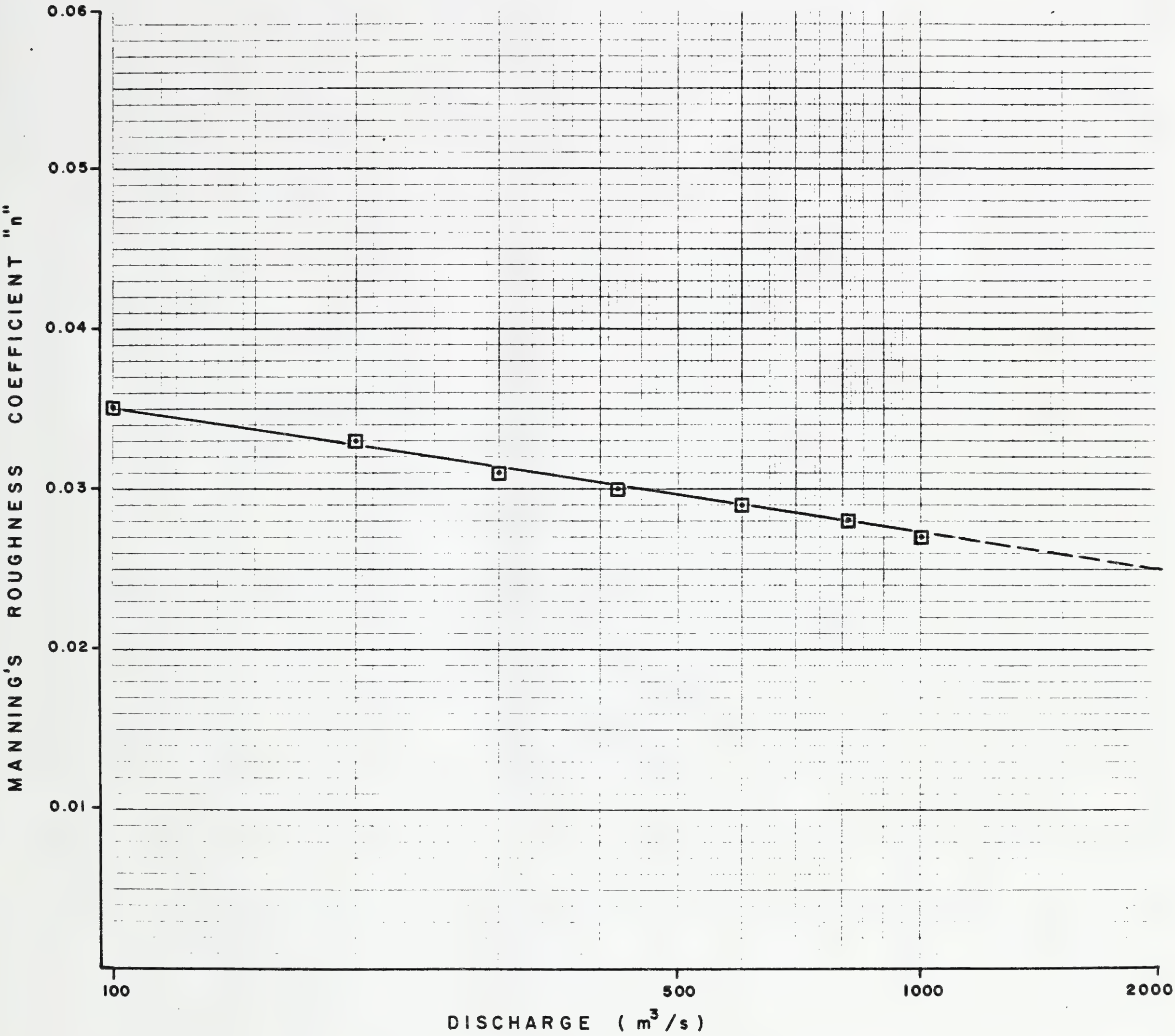
COCHRANE FLOODPLAIN STUDY

STAGE–DISCHARGE CURVE
BOW RIVER – 1916 FLOOD

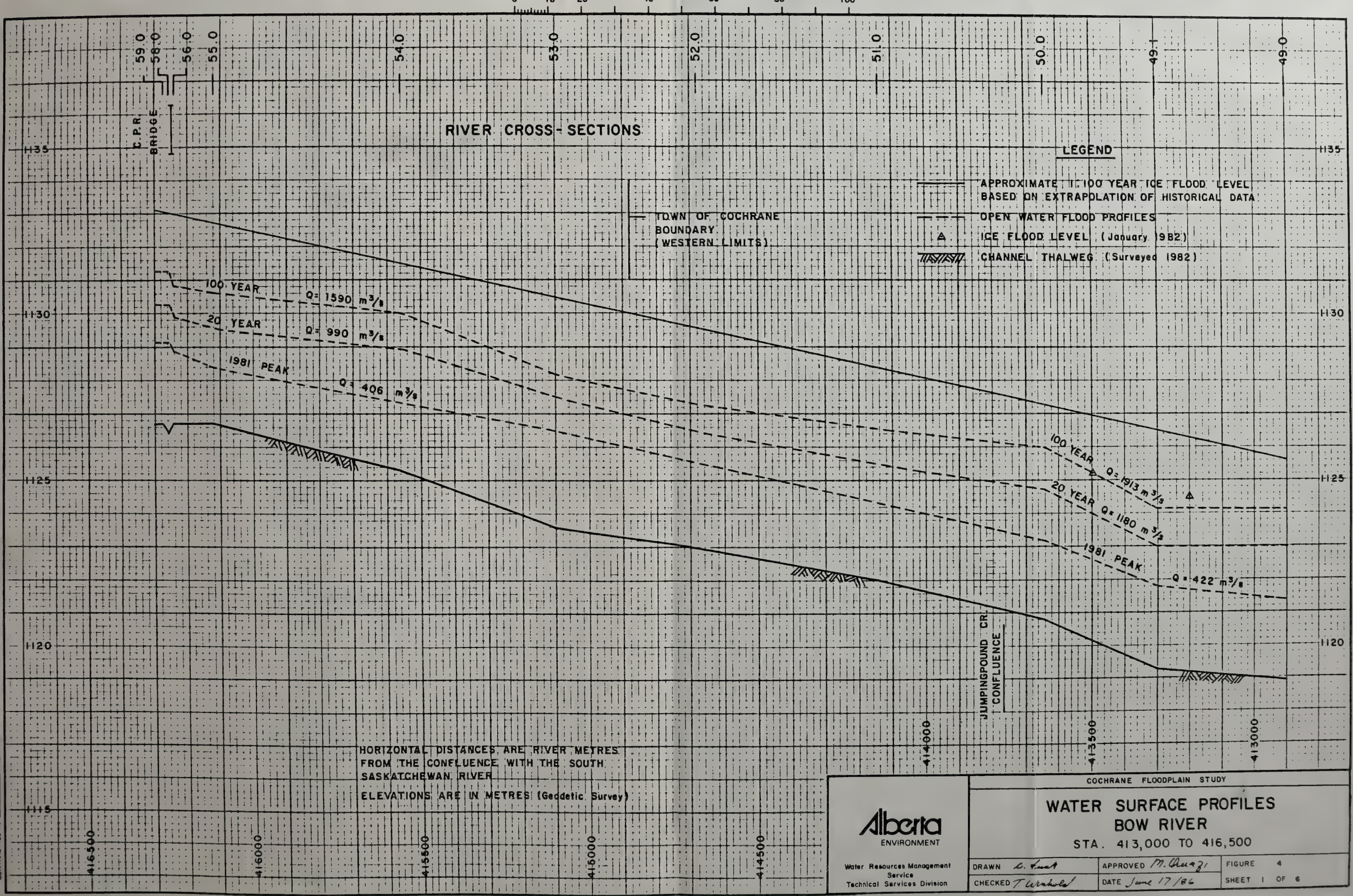
DRAWN BY:
CHECKED BY:
APPROVED BY: M. Quazi
DATE: June 17/86

FIGURE No. 2



⊡ Roughness Value Computed (HEC-2 MODEL) by direct calibration with stage-discharge curve, Figure 2.

Alberta ENVIRONMENT Water Resources Management Service ·Technical Services Division	COCHRANE FLOODPLAIN STUDY CHANNEL ROUGHNESS VALUES BOW RIVER AT COCHRANE		
	DRAWN BY : E. Beulanger	APPROVED BY : M. Quazi	FIGURE No. 3
	CHECKED BY : T. Winhold	DATE : June 17/86	



HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER

ELEVATIONS ARE IN METRES (Geodetic Survey)

COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER
STA. 413,000 TO 416,500

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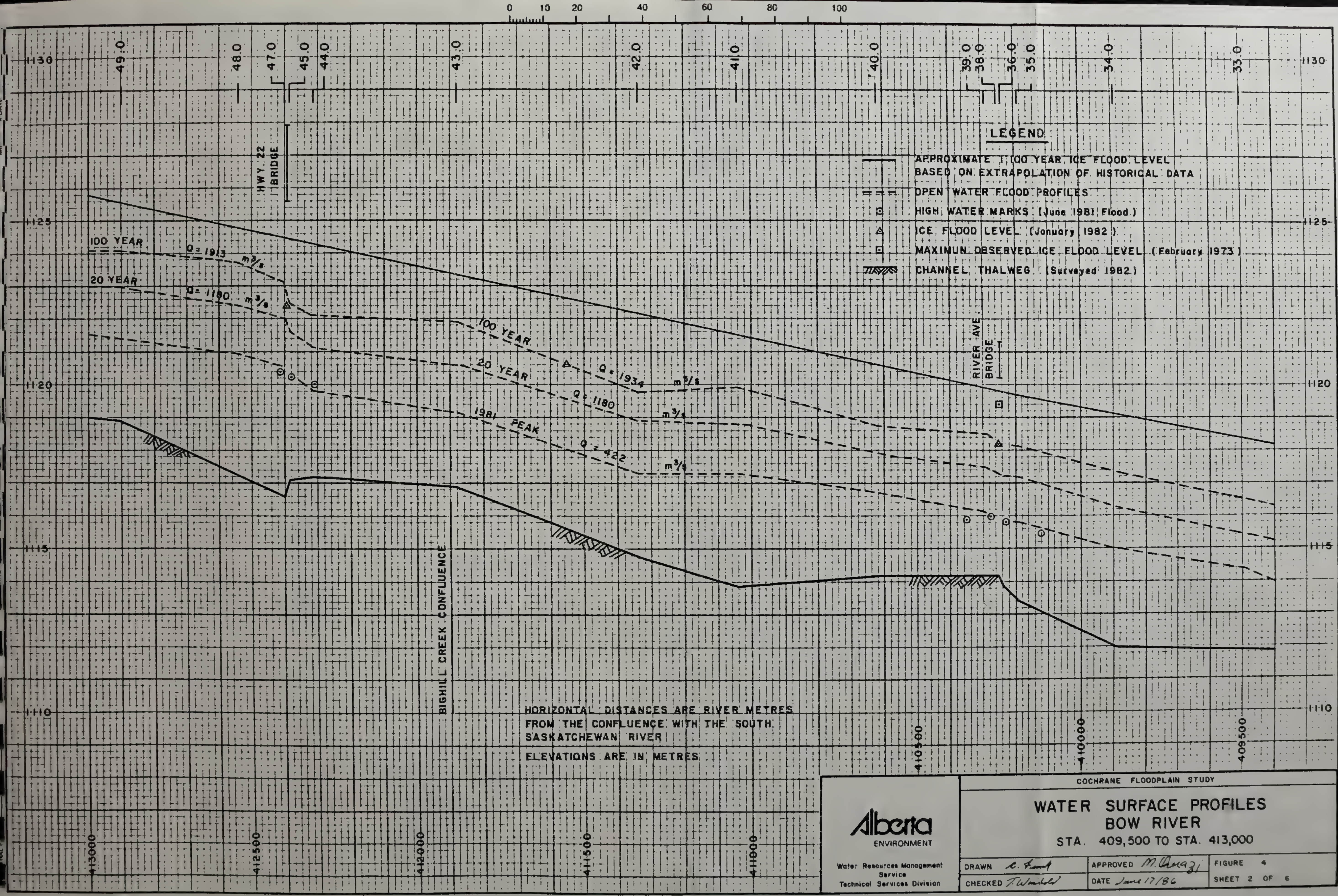
Water Resources Management Service
Technical Services Division

DRAWN C. Lust	APPROVED M. Quazi	FIGURE 4
CHECKED T. Wrakold	DATE June 17/86	SHEET 1 OF 6

MICROFILM DATE
DRAWING FILE No
CENTRAL FILE No 48

P3-280 x 430



HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER

ELEVATIONS ARE IN METRES

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ENVIRONMENT

Water Resources Management Service
Technical Services Division

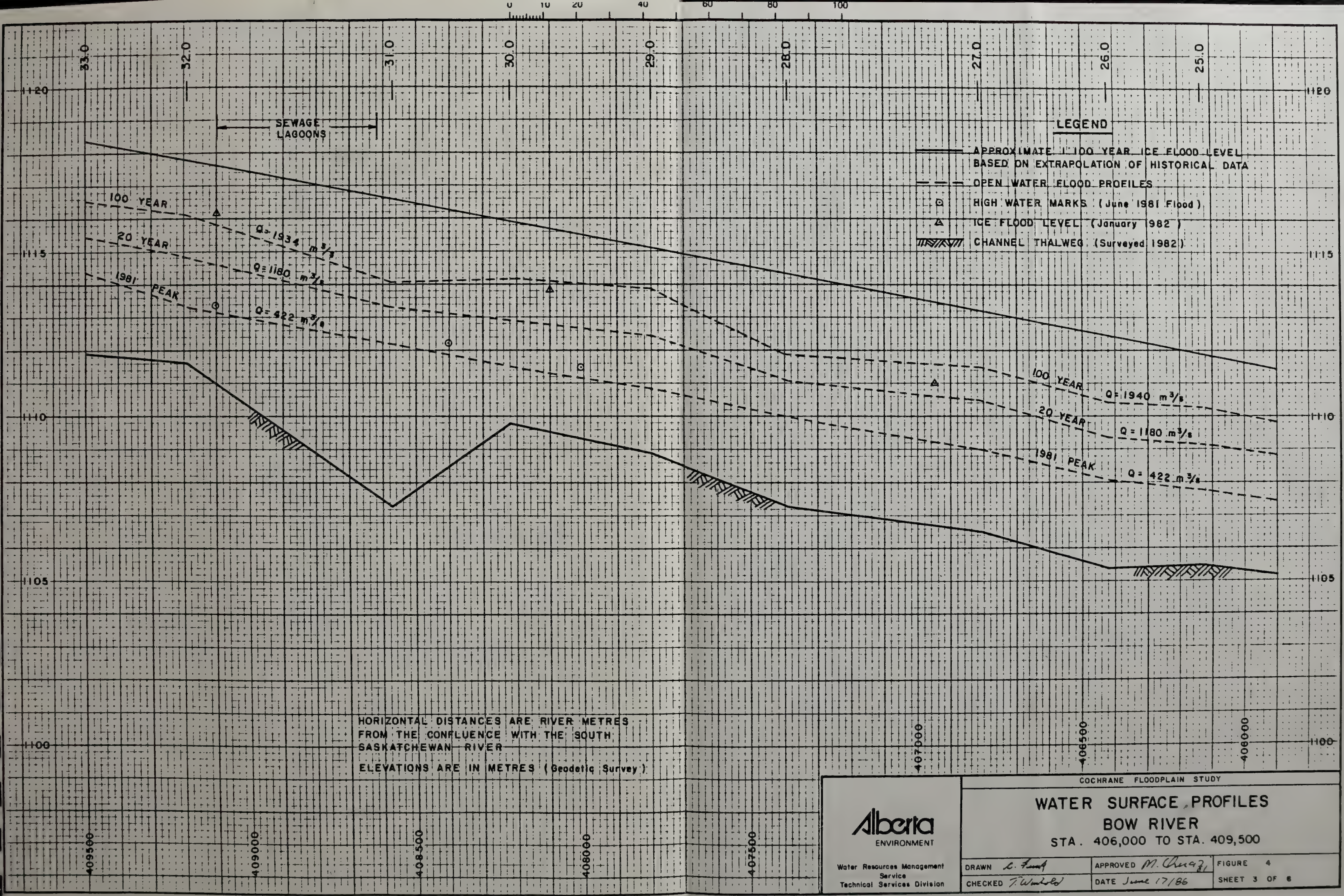
COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER

STA. 409,500 TO STA. 413,000

DRAWN	APPROVED	FIGURE 4
CHECKED	DATE June 17/86	SHEET 2 OF 6

P3-280 x 430



LEGEND

- APPROXIMATE 1:100 YEAR ICE FLOOD LEVEL BASED ON EXTRAPOLATION OF HISTORICAL DATA
- OPEN WATER FLOOD PROFILES
- ⊙ HIGH WATER MARKS (June 1981 Flood)
- △ ICE FLOOD LEVEL (January 1982)
- CHANNEL THALWEG (Surveyed 1982)

HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER

ELEVATIONS ARE IN METRES (Geodetic Survey)

Alberta
ENVIRONMENT

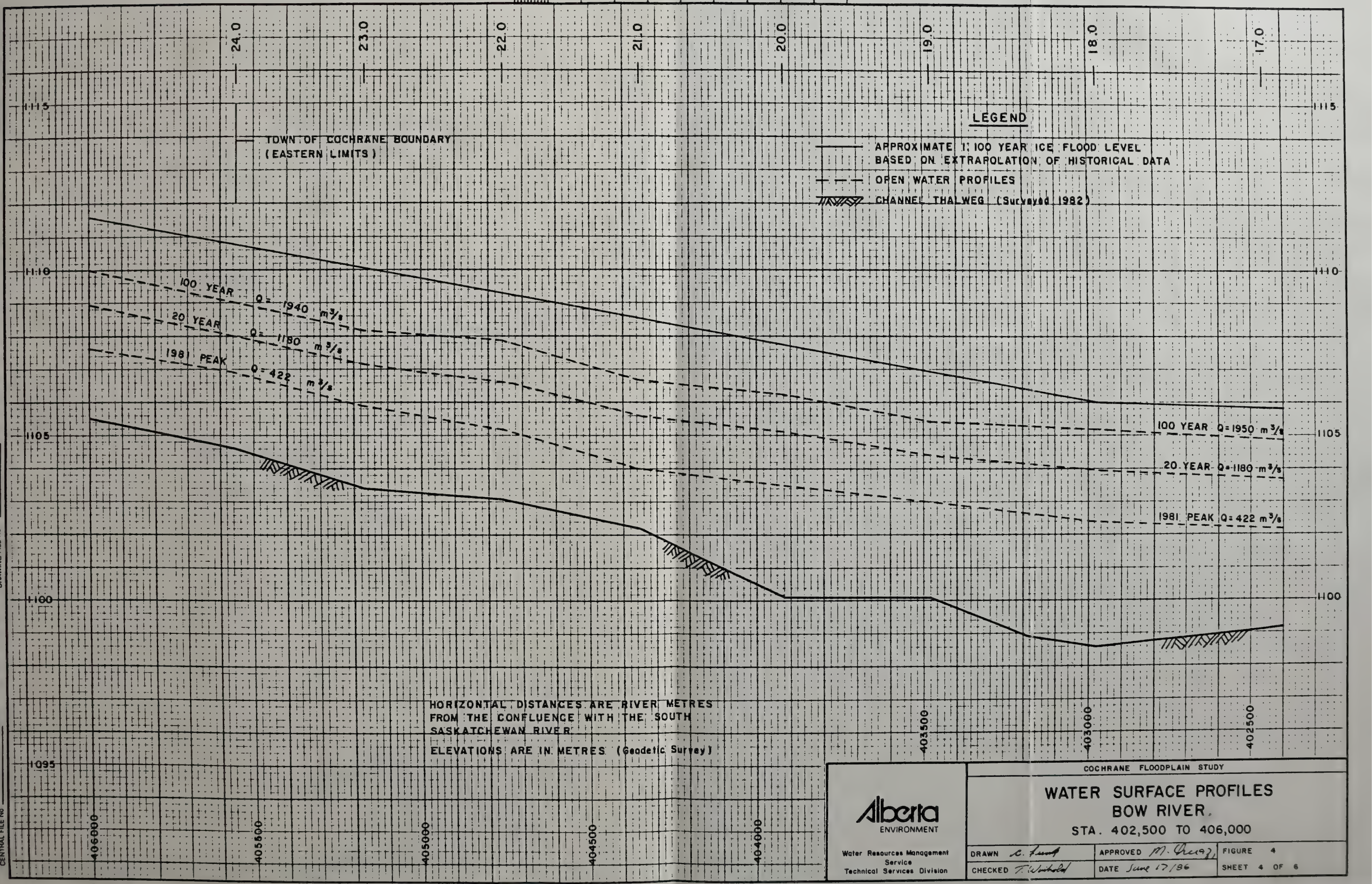
Water Resources Management
Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER
STA. 406,000 TO STA. 409,500

DRAWN
CHECKED
APPROVED
DATE June 17/86
FIGURE 4
SHEET 3 OF 6

P3-280 x 430



LEGEND

- APPROXIMATE 1:100 YEAR ICE FLOOD LEVEL BASED ON EXTRAPOLATION OF HISTORICAL DATA
- OPEN WATER PROFILES
- CHANNEL THALWEG (Surveyed 1982)

HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER.

ELEVATIONS ARE IN METRES (Geodetic Survey)

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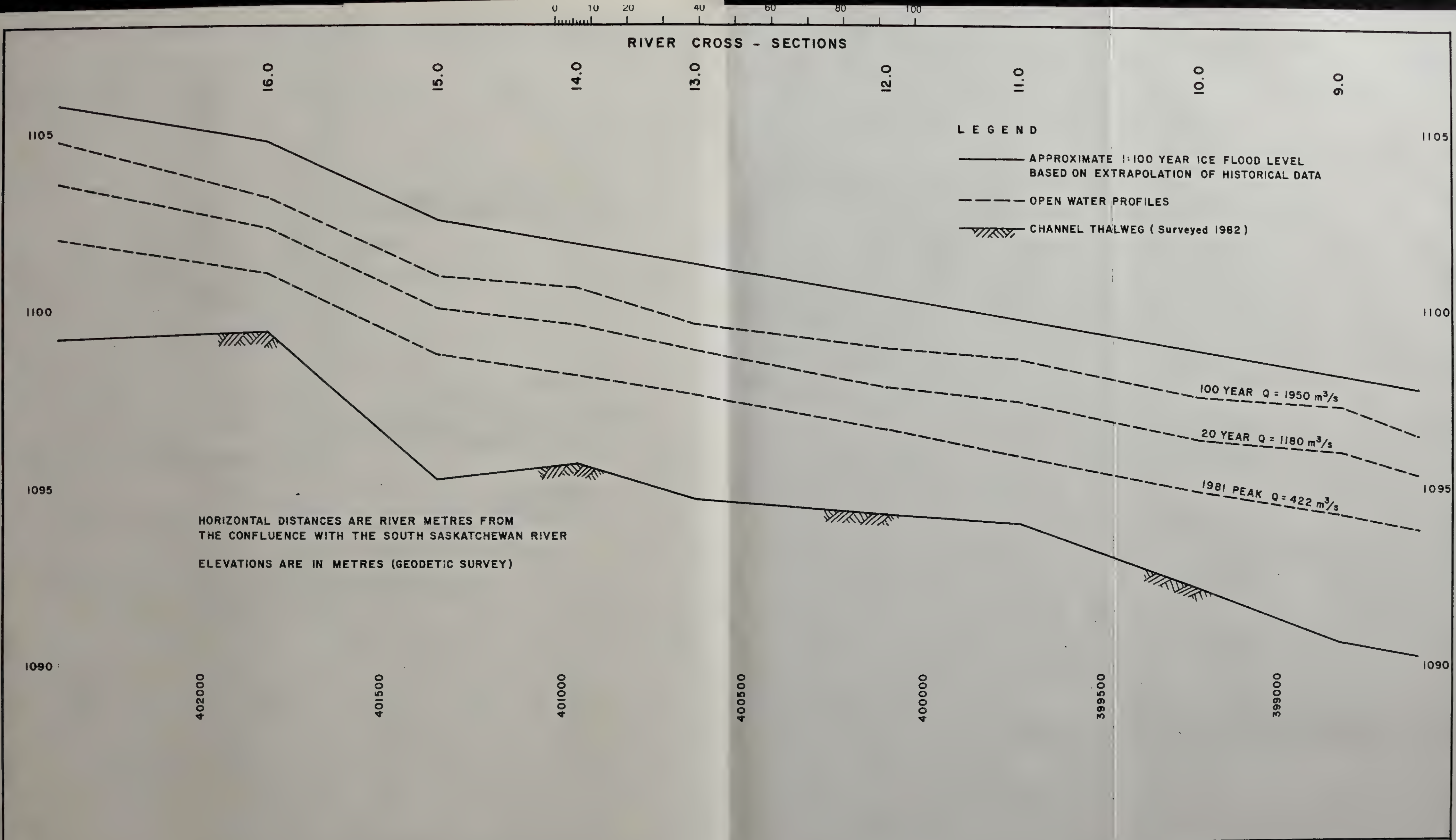
COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER.
STA. 402,500 TO 406,000

DRAWN
APPROVED
FIGURE 4
CHECKED
DATE June 17/86
SHEET 4 OF 6



HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER

ELEVATIONS ARE IN METRES (GEODETIC SURVEY)

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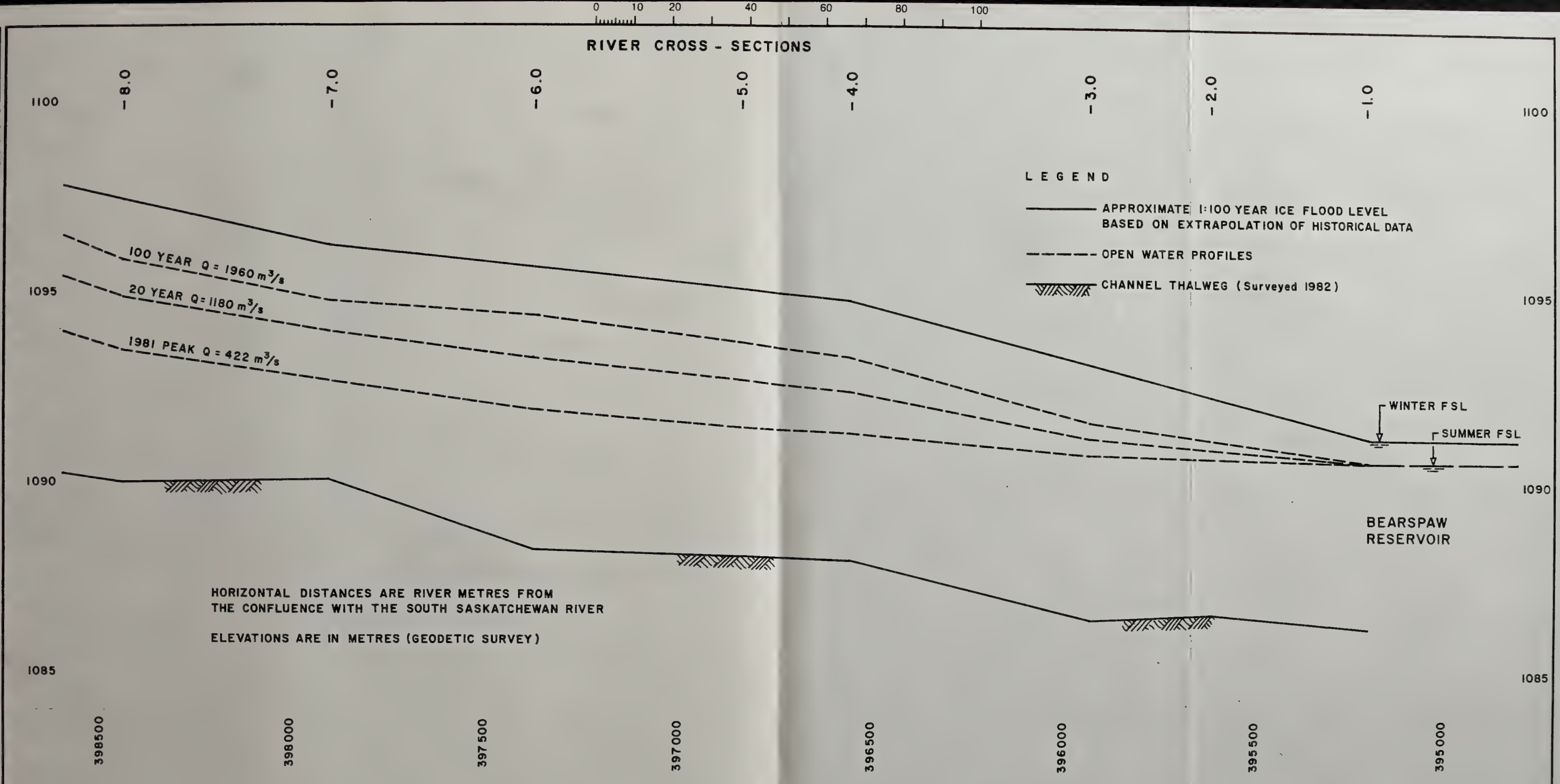
COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER
STA. 398600 TO 402500

DRAWN : g.s.b.
CHECKED : T. Winhold
APPROVED :
DATE : June 17/86
FIGURE 4
SHEET 5 OF 6

P3-280 x 430



HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE SOUTH SASKATCHEWAN RIVER

ELEVATIONS ARE IN METRES (GEODETIC SURVEY)

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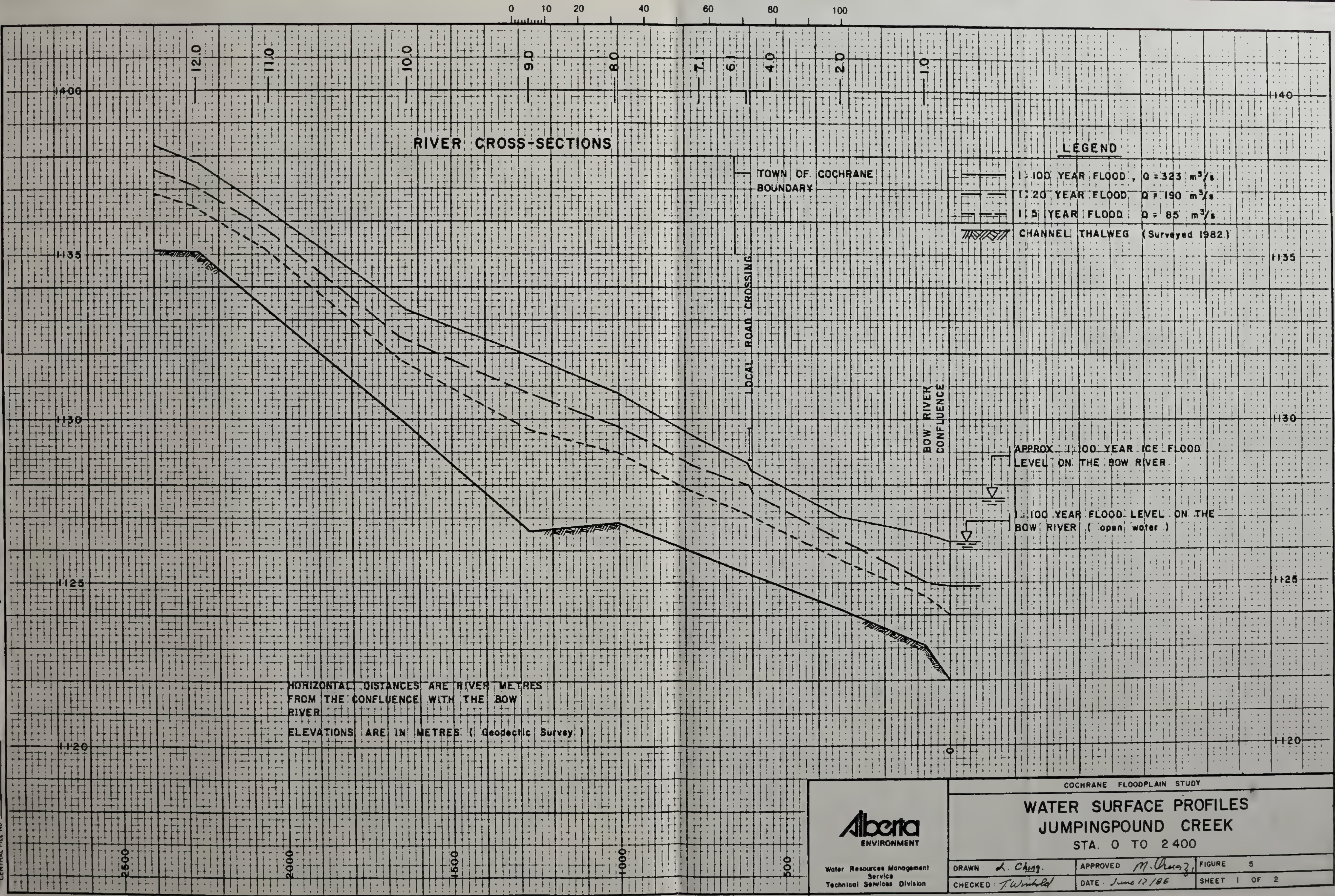
Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BOW RIVER
STA. 395 200 TO 398 600

DRAWN : g.s.b.	APPROVED : M. Chaz	FIGURE 4
CHECKED : T. Winhold	DATE : June 17/86	SHEET 6 OF 6

P3-280 x 430



COCHRANE FLOODPLAIN STUDY

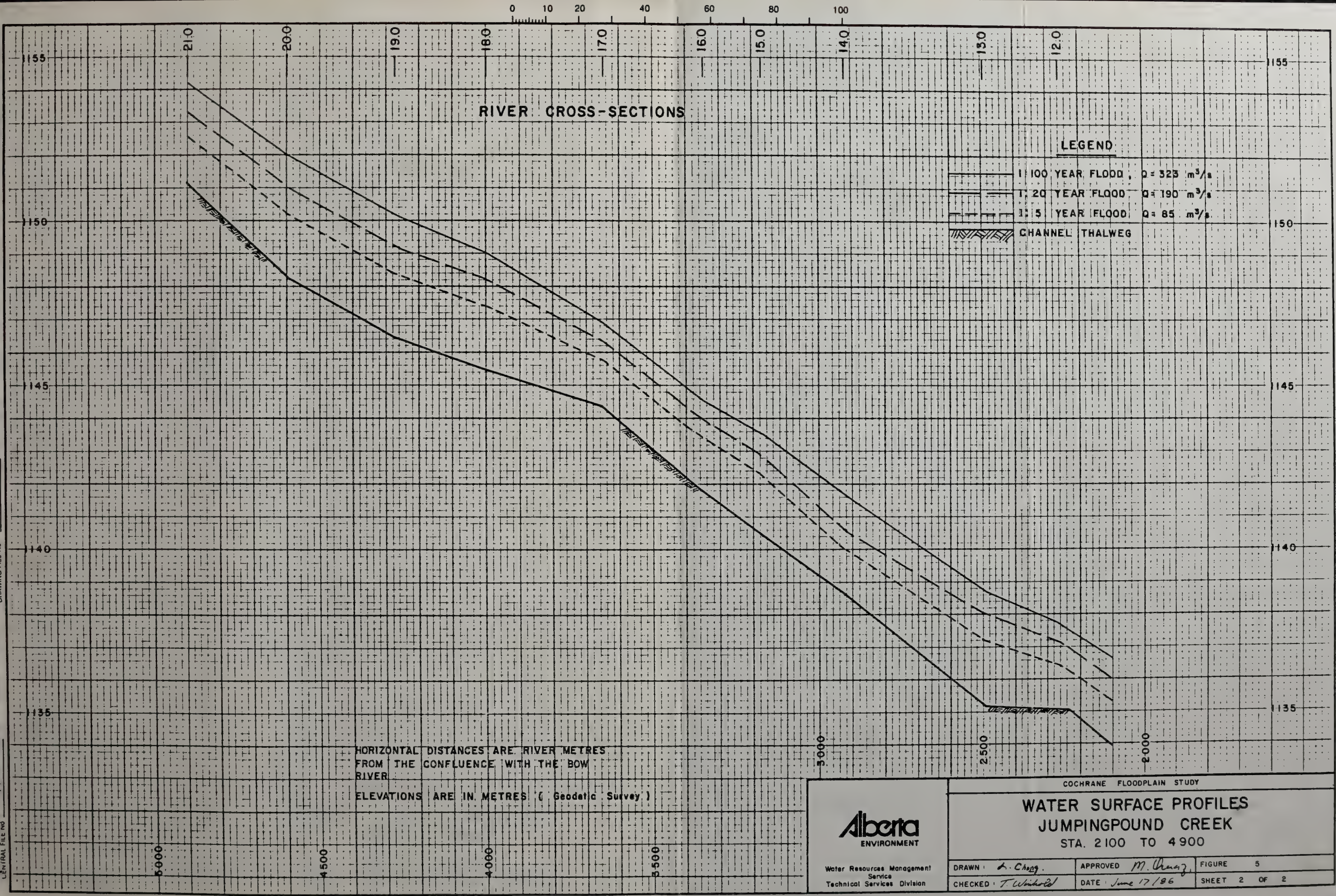
WATER SURFACE PROFILES
JUMPINGPOUND CREEK

STA. 0 TO 2 400

Alberta
ENVIRONMENT

Water Resources Management Service
Technical Services Division

DRAWN: L. Cheng.	APPROVED	FIGURE 5
CHECKED: T. Winhold	DATE: June 17/86	SHEET 1 OF 2



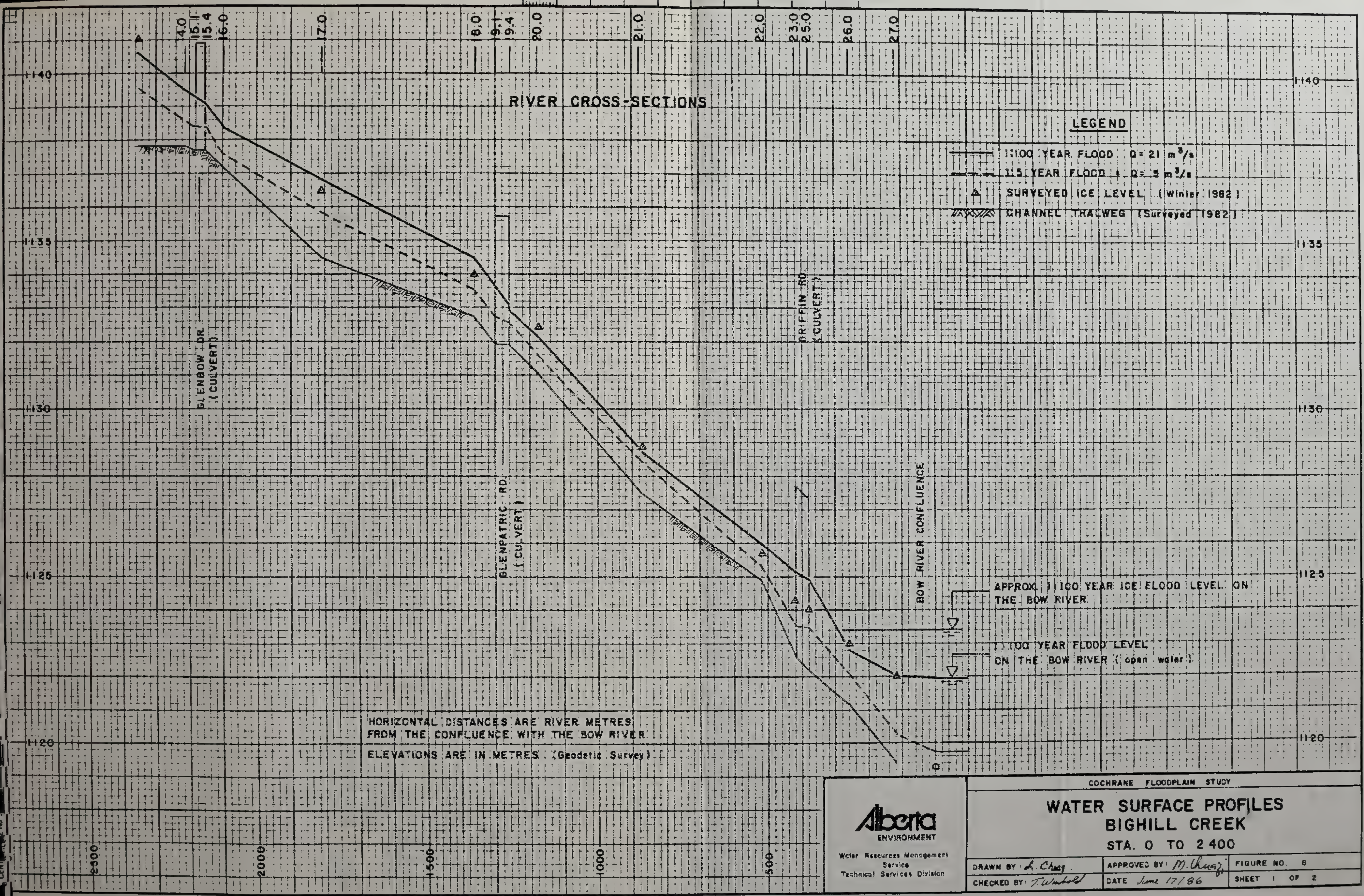
COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
JUMPINGPOUND CREEK
STA. 2100 TO 4900

Alberta ENVIRONMENT

Water Resources Management Service
Technical Services Division

DRAWN: L. Chong.	APPROVED M. Chang.	FIGURE 5
CHECKED: T. Winhold	DATE: June 17/86	SHEET 2 OF 2



HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE BOW RIVER

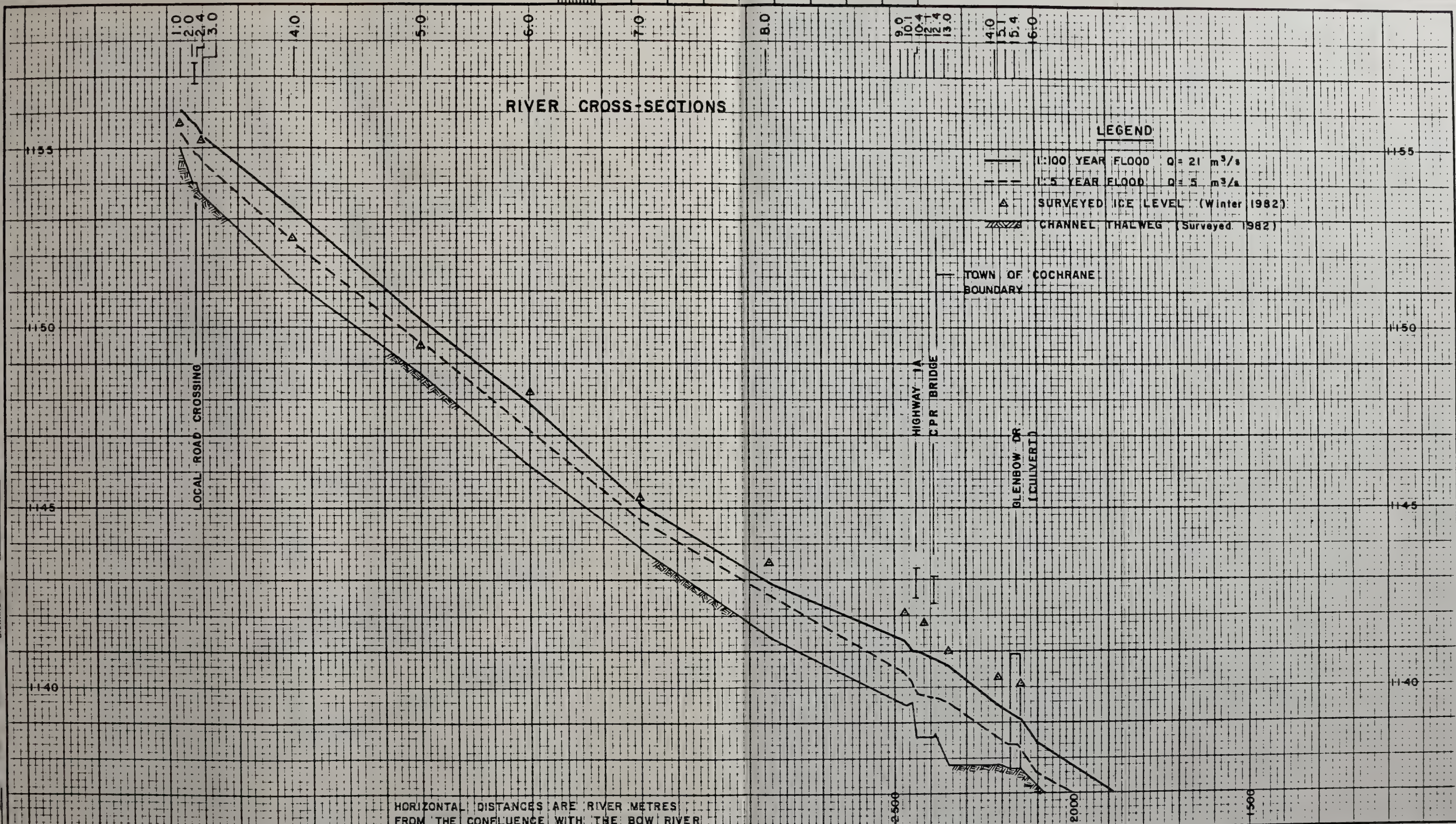
ELEVATIONS ARE IN METRES (Geodetic Survey)

COCHRANE FLOODPLAIN STUDY

WATER SURFACE PROFILES
BIGHILL CREEK
STA. 0 TO 2 400

Alberta
ENVIRONMENT
Water Resources Management
Service
Technical Services Division

DRAWN BY: L. Chang.
CHECKED BY: T. Winhold
APPROVED BY: M. Chuaz.
DATE June 17/86
FIGURE NO. 6
SHEET 1 OF 2



LEGEND

——	1:100 YEAR FLOOD Q = 21 m³/s
– – –	1:5 YEAR FLOOD Q = 5 m³/s
△	SURVEYED ICE LEVEL (Winter 1982)
▨	CHANNEL THALWEG (Surveyed 1982)

HORIZONTAL DISTANCES ARE RIVER METRES FROM THE CONFLUENCE WITH THE BOW RIVER

ELEVATIONS ARE IN METRES (Geodetic Survey)

Alberta
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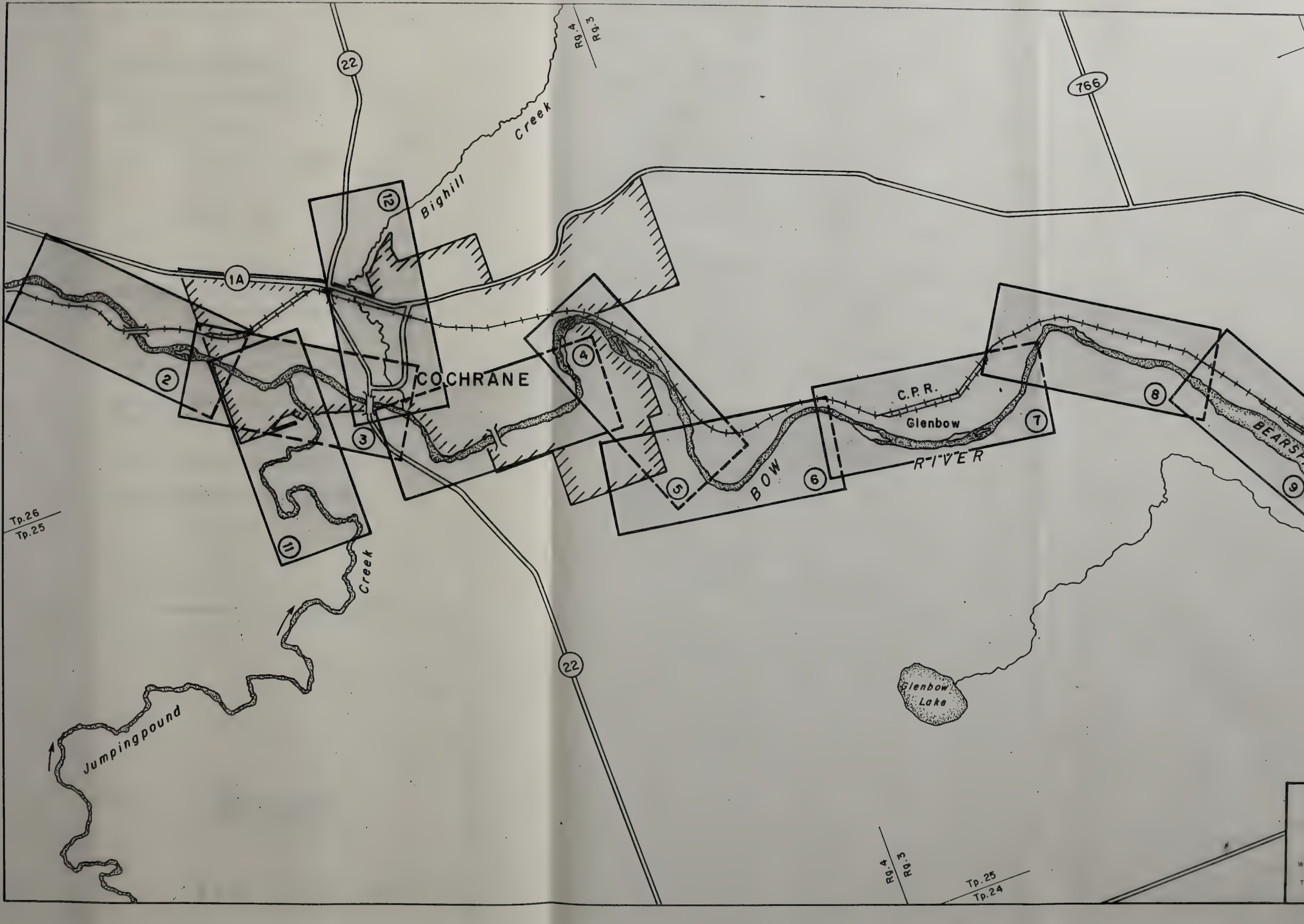
Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

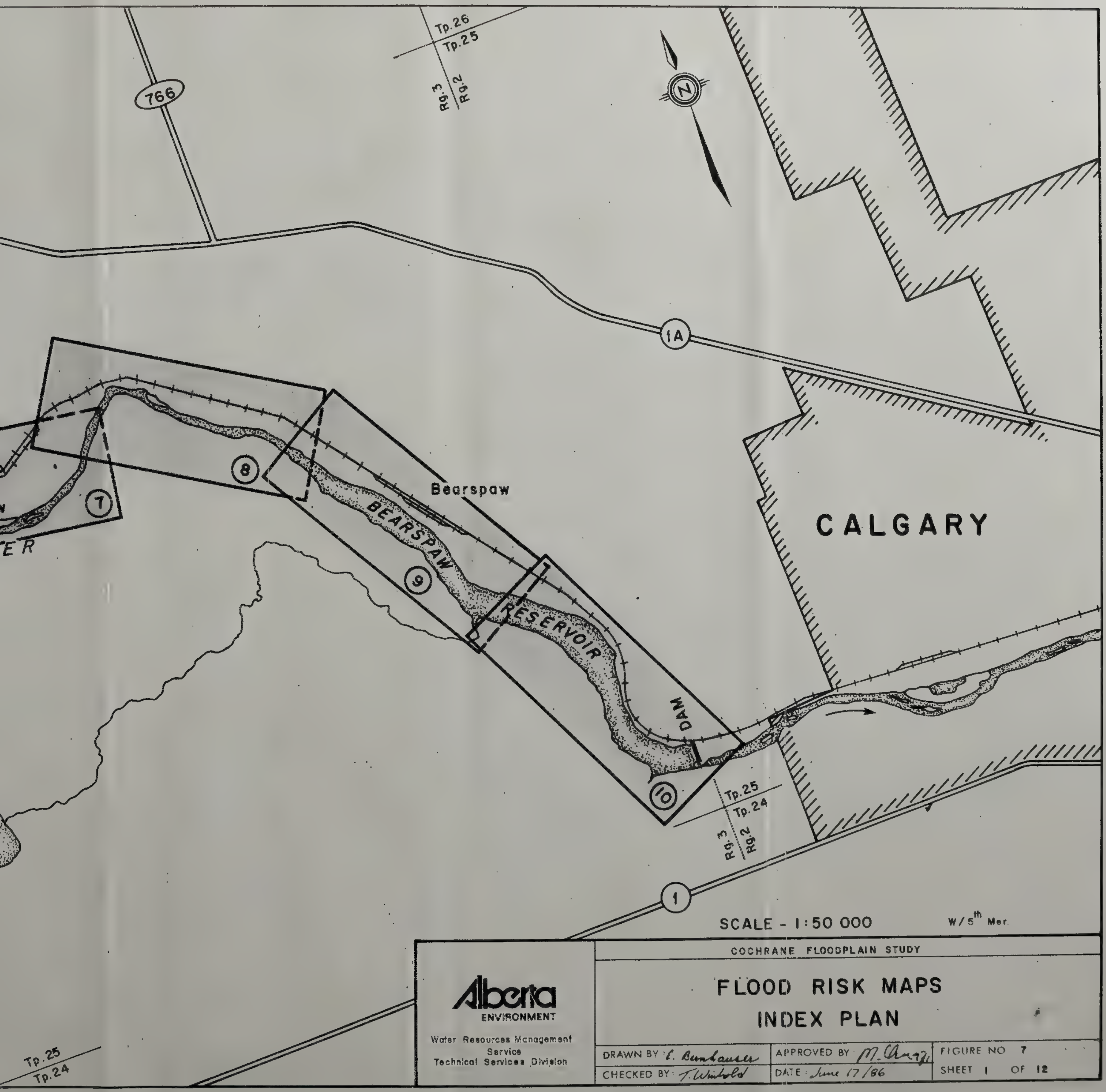
WATER SURFACE PROFILES
BIGHILL CREEK
STA. 1900 TO 4500

DRAWN BY: L. Chng.	APPROVED BY: M. Chrosz	FIGURE NO. 6
CHECKED BY: T. Winhold	DATE: June 17/86	SHEET 2 OF 2

P3-280 x 430



RECR 58
AB #270



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Water Resources Management
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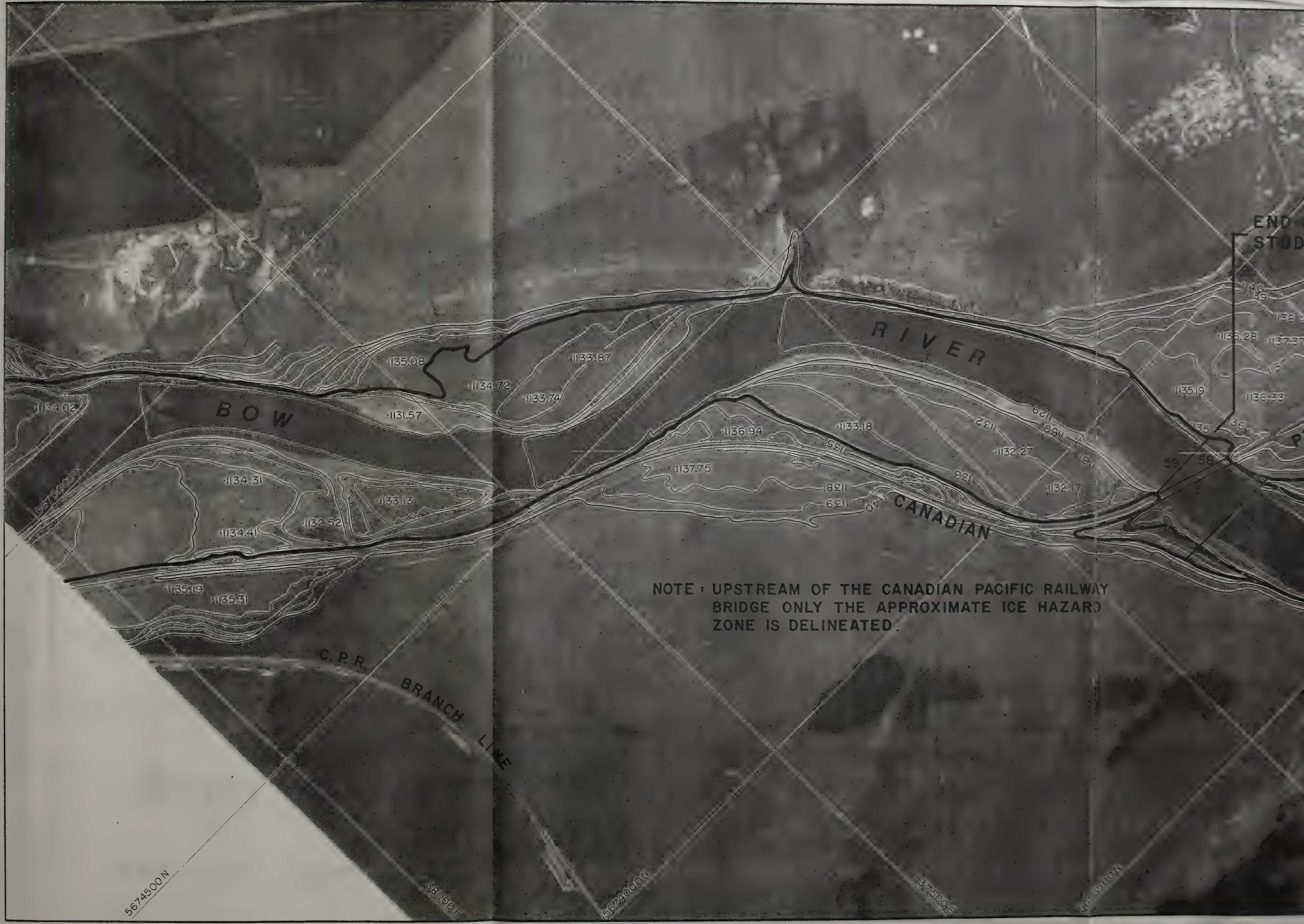
COCHRANE FLOODPLAIN STUDY

FLOOD RISK MAPS
INDEX PLAN

DRAWN BY: E. Bumhauser	APPROVED BY: M. Chagzi	FIGURE NO 7
CHECKED BY: T. Winkold	DATE: June 17/86	SHEET 1 OF 12



NOTE: UPSTREAM OF THE CANADIAN PACIFIC RAILWAY BRIDGE ONLY THE APPROXIMATE ICE HAZARD ZONE IS DELINEATED.

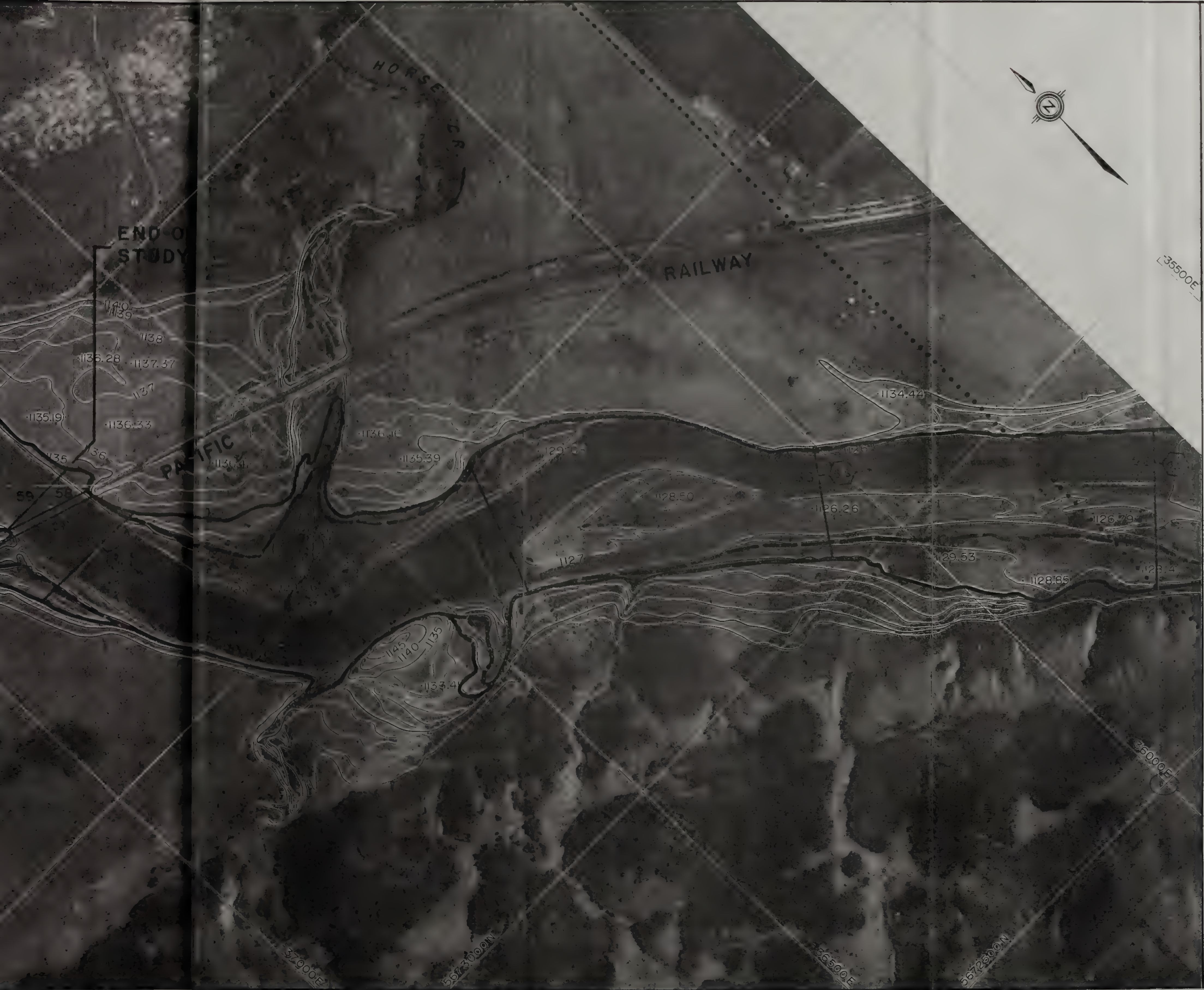


FIGURE 7, SHEET 2

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe		1:100 Year Flood Risk Area (Ice Hazard Zone)
	Floodway	
Flood Fringe		

- - - - 1:100 Year Open Water Flood Limits

49 → Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

.... Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

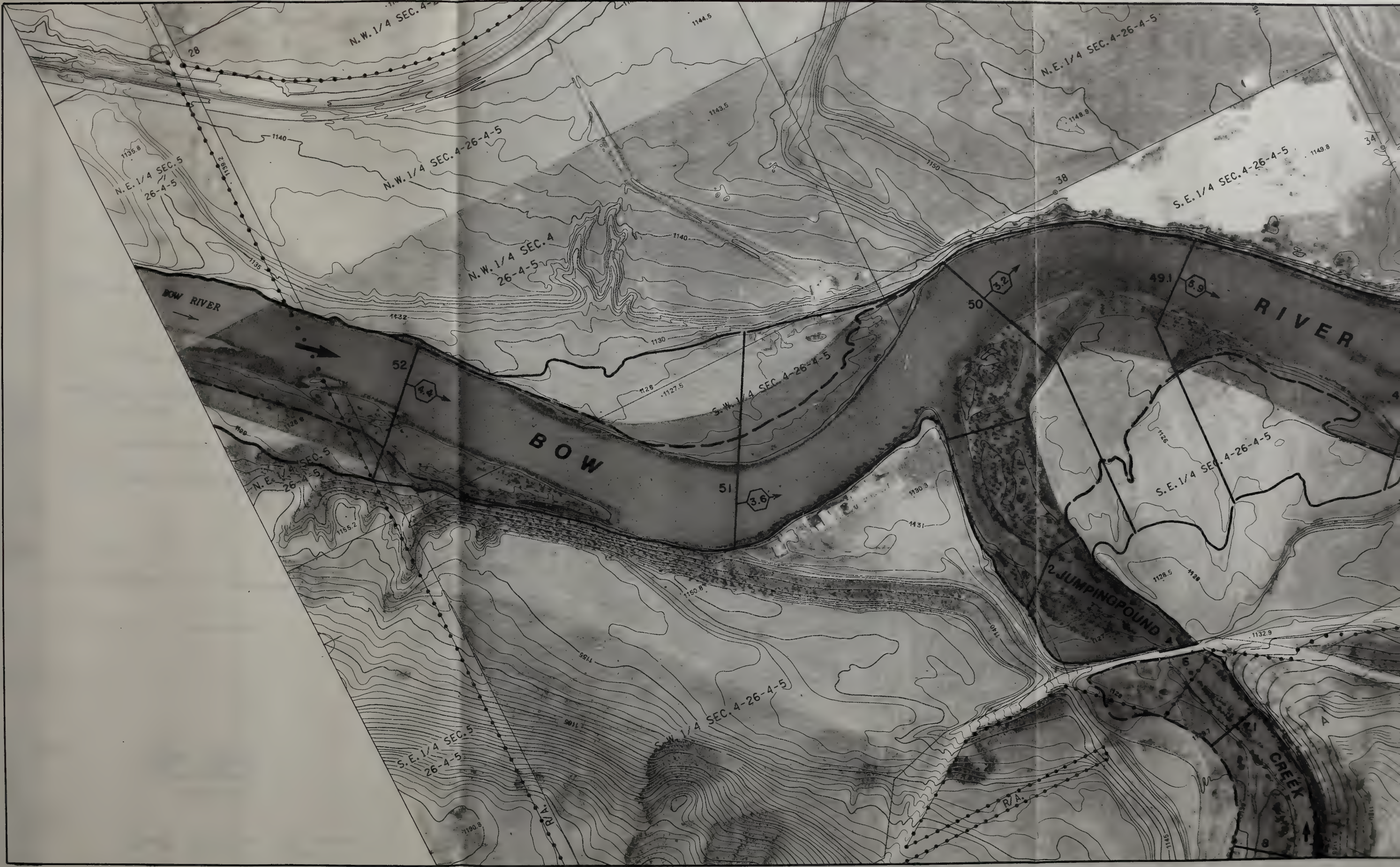
• BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO	MAY, 1983
CONTOUR INTERVAL	1.0 metre

Canada-Alberta FLOOD DAMAGE REDUCTION PROGRAM

Alberta ENVIRONMENT

Environment Canada Environnement Canada


N.W. 1/4 SEC. 4-
1144.5
28
N.E. 1/4 SEC. 4-26-4-5
1143.5
1149.9
34
1140
N.W. 1/4 SEC. 4-26-4-5
1135.8
N.E. 1/4 SEC. 5
26-4-5
1138.2
1150
38
S.E. 1/4 SEC. 4-26-4-5
1149.8
1140
1135
N.W. 1/4 SEC. 4
26-4-5
BOW RIVER
1132
1130
52
4.4
1125
1127.5
S.W. 1/4 SEC. 4-26-4-5
50
3.2
49.1
5.9
RIVER
BOW
1126
S.E. 1/4 SEC. 4-26-4-5
51
3.6
1130.3
1131
N.E. 1/4 SEC. 5
26-4-5
1155.2
1150.8
2
JUMPINGPOUND
1128.5
1129
1132.9
1155
1165
S.W. 1/4 SEC. 4-26-4-5
S.E. 1/4 SEC. 5
26-4-5
R/A.
R/A.
6
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1145
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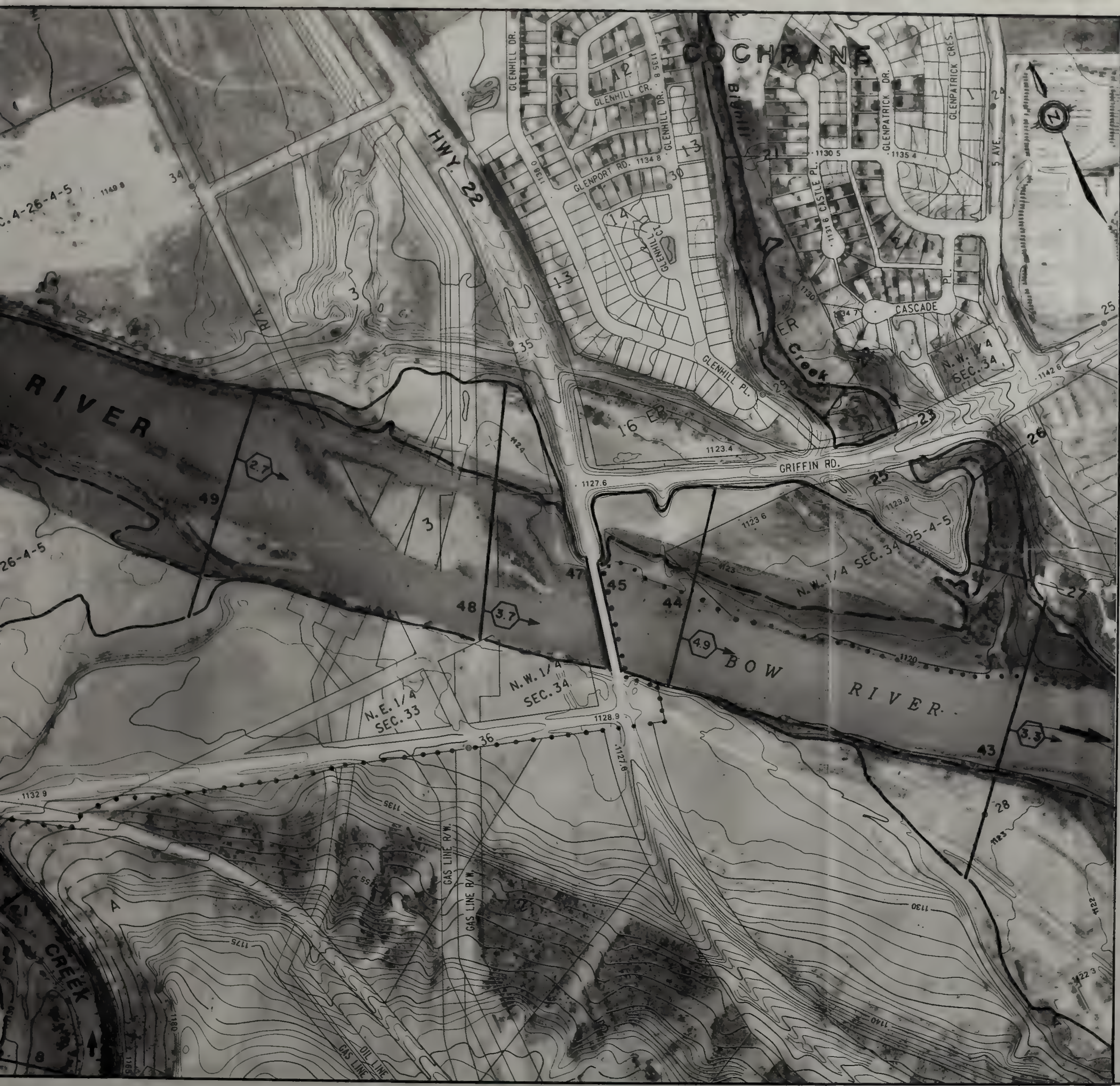


FIGURE 7, SHEET 3

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway
Flood Fringe
1:100 Year Flood Risk Area (Ice Hazard Zone)

1:100 Year Open Water Flood Limits

4.9 Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

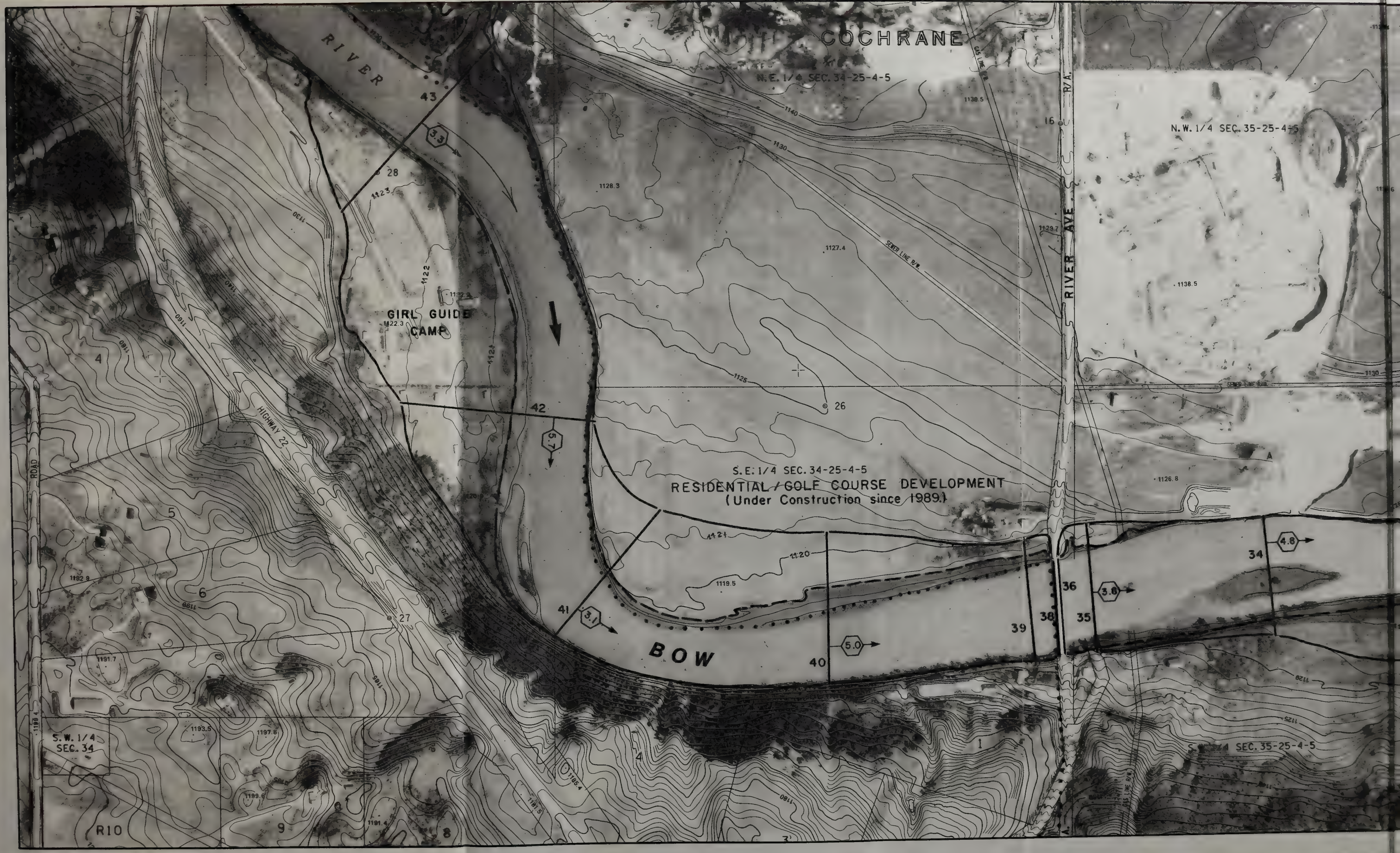
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1982

ORTHOPHOTO .... MAY, 1981
CONTOUR INTERVAL .... 1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada
Environnement Canada


COCHRANE
N.E. 1/4 SEC. 34-25-4-5
N.W. 1/4 SEC. 35-25-4-5
RIVER
BOW
RIVER AVE
R/A
GIRL GUIDE CAMP
HIGHWAY 22
ROAD
S.E. 1/4 SEC. 34-25-4-5
RESIDENTIAL / GOLF COURSE DEVELOPMENT
(Under Construction since 1989.)
S.W. 1/4 SEC. 34
SEC. 35-25-4-5
SEWER LINE R/W
GAS LINE R/W
R10
43
42
41
40
39
38
36
35
34
3.3
5.7
3.1
5.0
3.6
4.8
28
26
27
16
1128.3
1127.4
1129.7
1130.5
1138.5
1126.8
1122.3
1119.5
1192.9
1191.7
1193.5
1197.8
1199.6
1191.4
1181.5
1186.4
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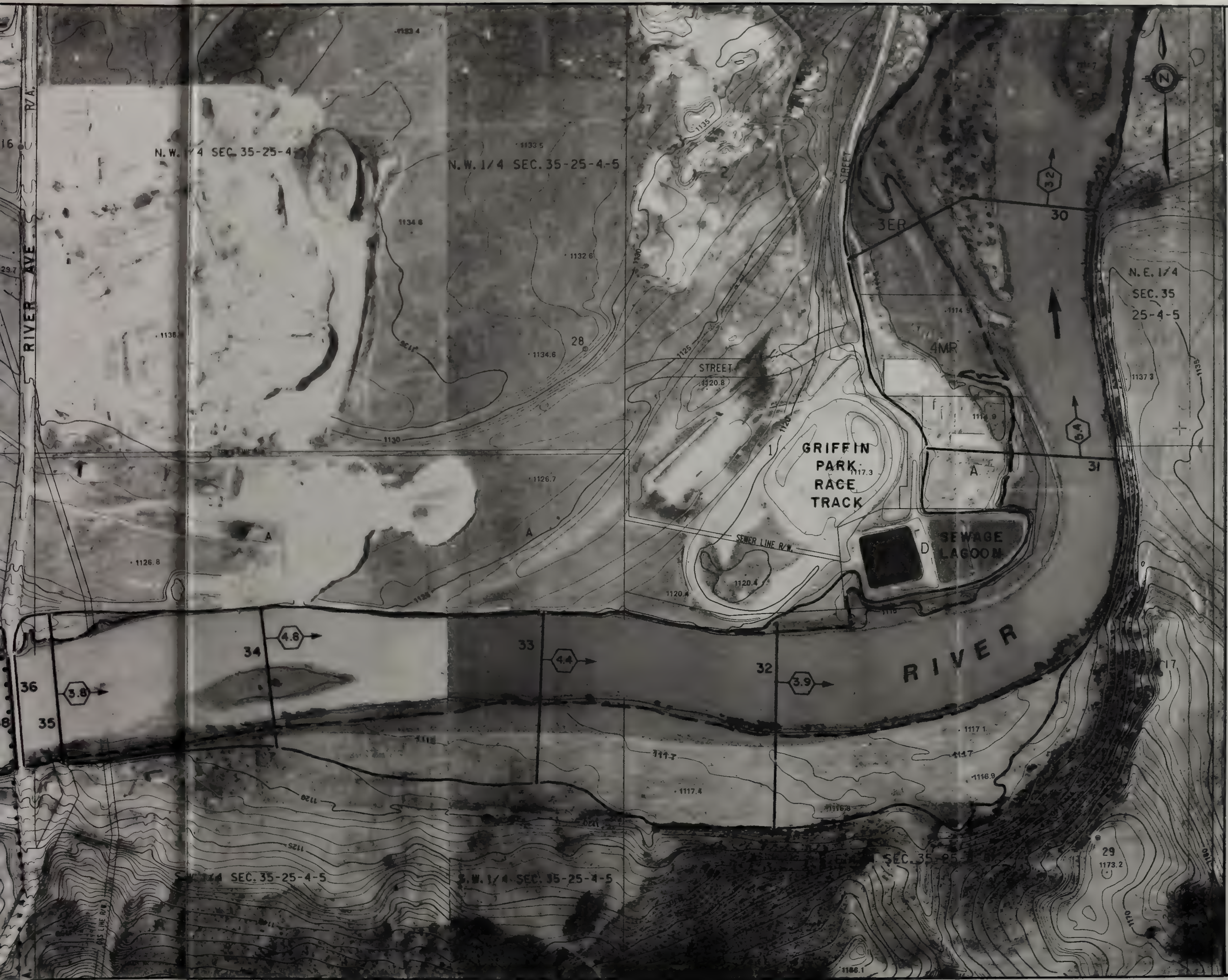


FIGURE 7, SHEET 4

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway
Flood Fringe
1:100 Year Flood Risk Area (Ice Hazard Zone)

1:100 Year Open Water Flood Limits

49 Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

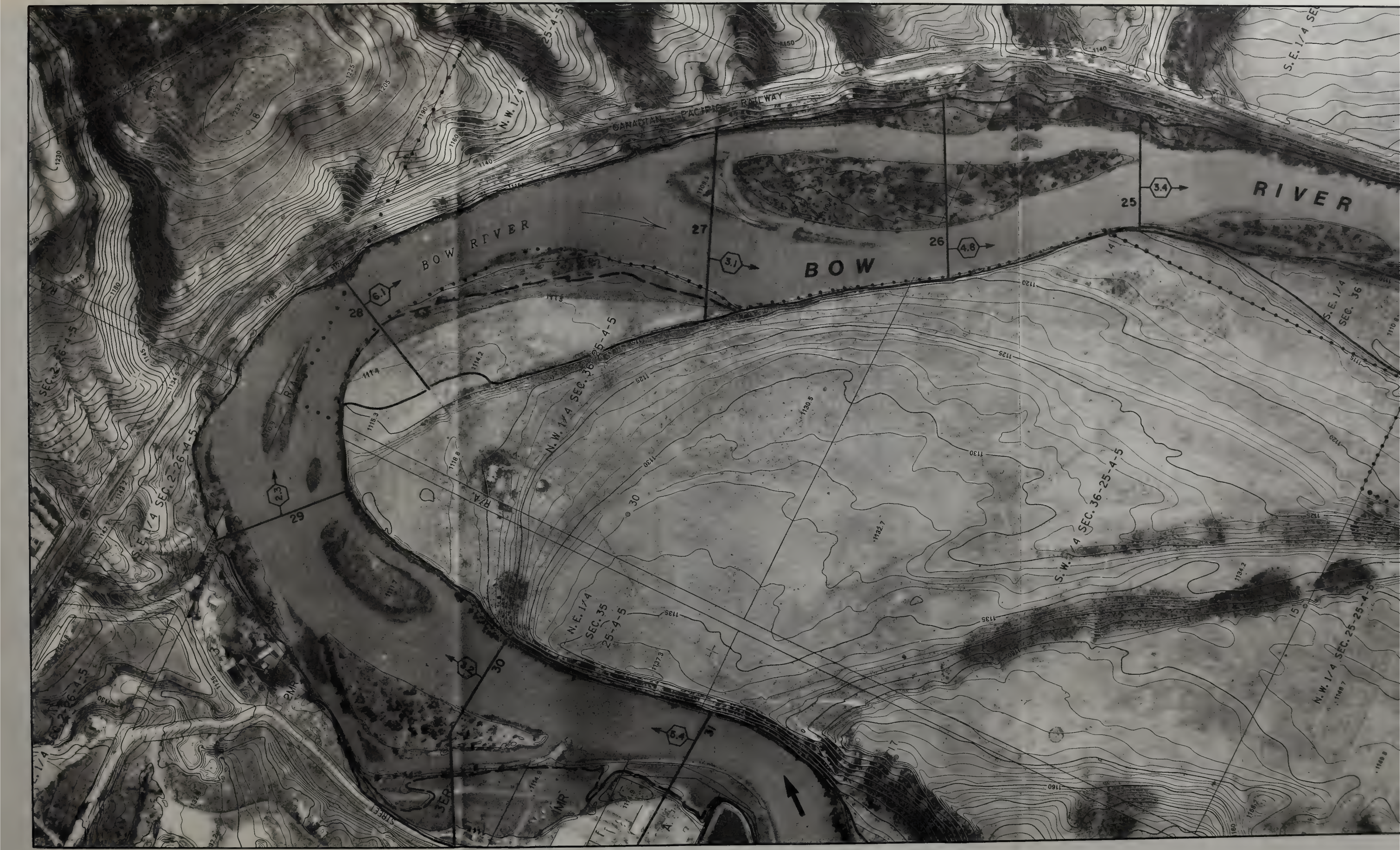
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1982

ORTHOPHOTO .... MAY, 1981
CONTOUR INTERVAL .... 1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada Environnement Canada


CANADIAN PACIFIC RAILWAY
BOW RIVER
BOW
RIVER
25
3.4
26
4.8
27
3.1
28
6.1
29
2.3
30
3.2
31
5.4
N.W. 1/4 SEC. 36-25-4-5
S.W. 1/4 SEC. 36-25-4-5
N.E. 1/4 SEC. 35 25-4-5
N.W. 1/4 SEC. 25-25-4-5
S.E. 1/4 SEC. 36
S.E. 1/4 SE
N.W. 1/4
25-4-5
S.E. 1/4 SEC. 2-26-4-5
SEC. 2-26-4-5
R/A
R/A
STREET
2MR
3ER
4MR
18
30
14
15
17
1120
1125
1130
1135
1140
1150
1160
1130.5
1132.7
1134.2
1118.8
1115.3
1114.2
1114
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1111.7
1137.3

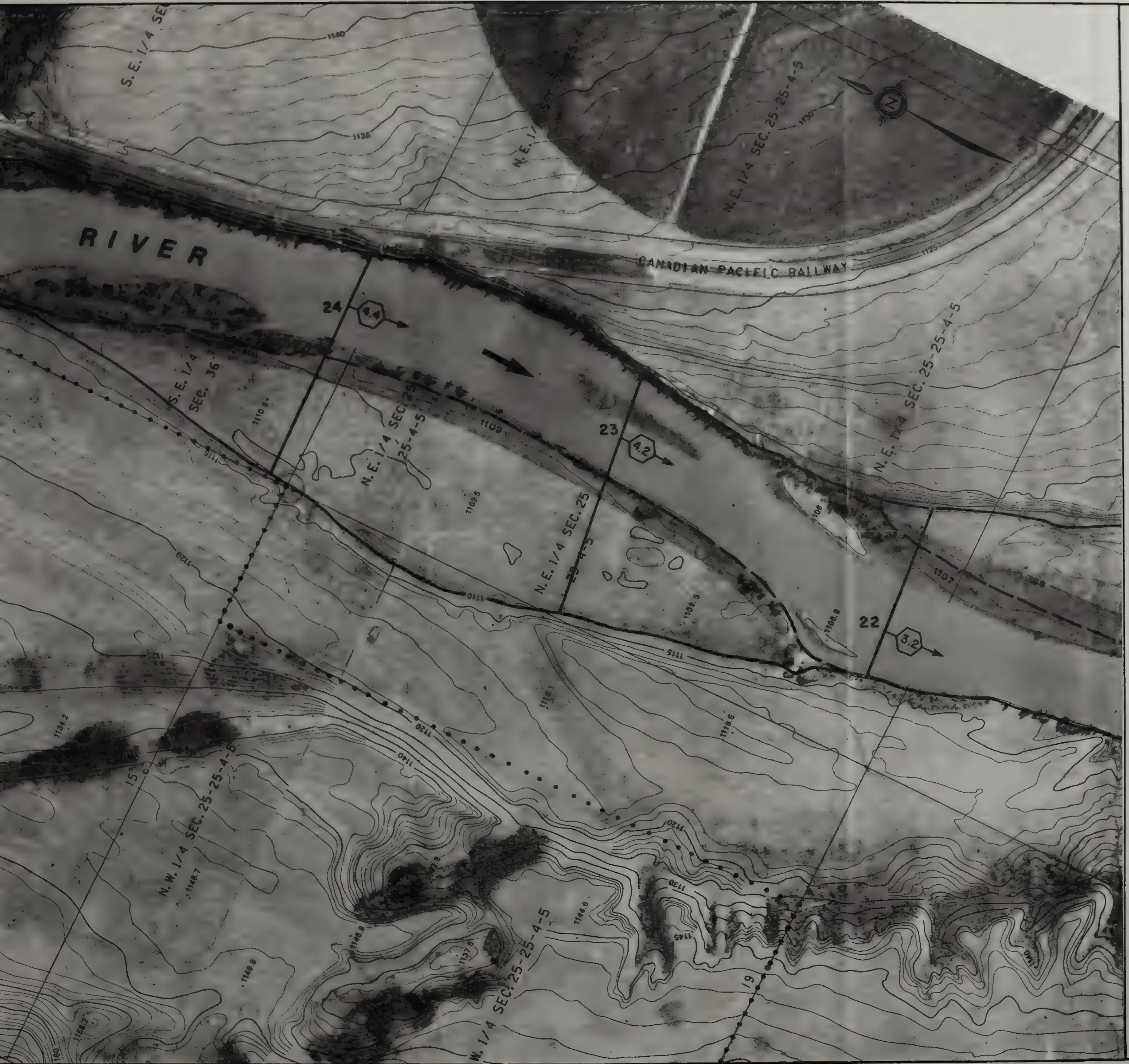


FIGURE 7, SHEET 5

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway
Flood Fringe
1:100 Year Flood Risk Area (Ice Hazard Zone)

— — — — 1:100 Year Open Water Flood Limits

⬡ 4.9 → Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

.... Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

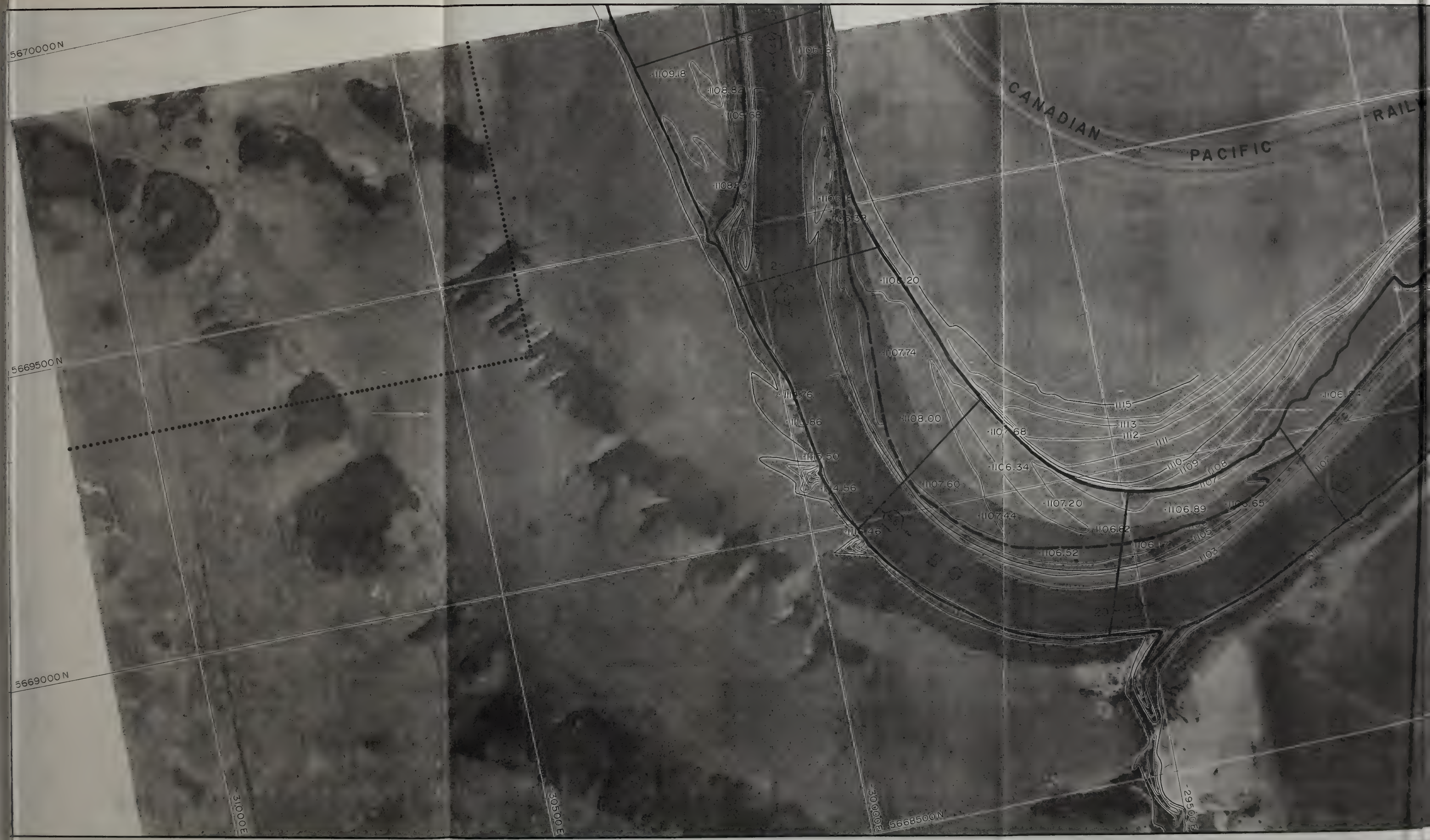
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1982

ORTHOPHOTO .... MAY, 1981
CONTOUR INTERVAL .... 1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada
Environnement Canada


5670000 N
5669500 N
5669000 N
5668500 N
31000 E
30500 E
30000 E
29500 E
CANADIAN
PACIFIC
RAIL
1109.18
1108.82
1109.68
1108.83
1105.38
1108.20
1107.74
1108.00
1107.68
1106.34
1107.60
1107.20
1107.44
1106.82
1106.52
1106.89
1115
1113
1112
1111
1110
1109
1108
1107
1105
1103
114.56

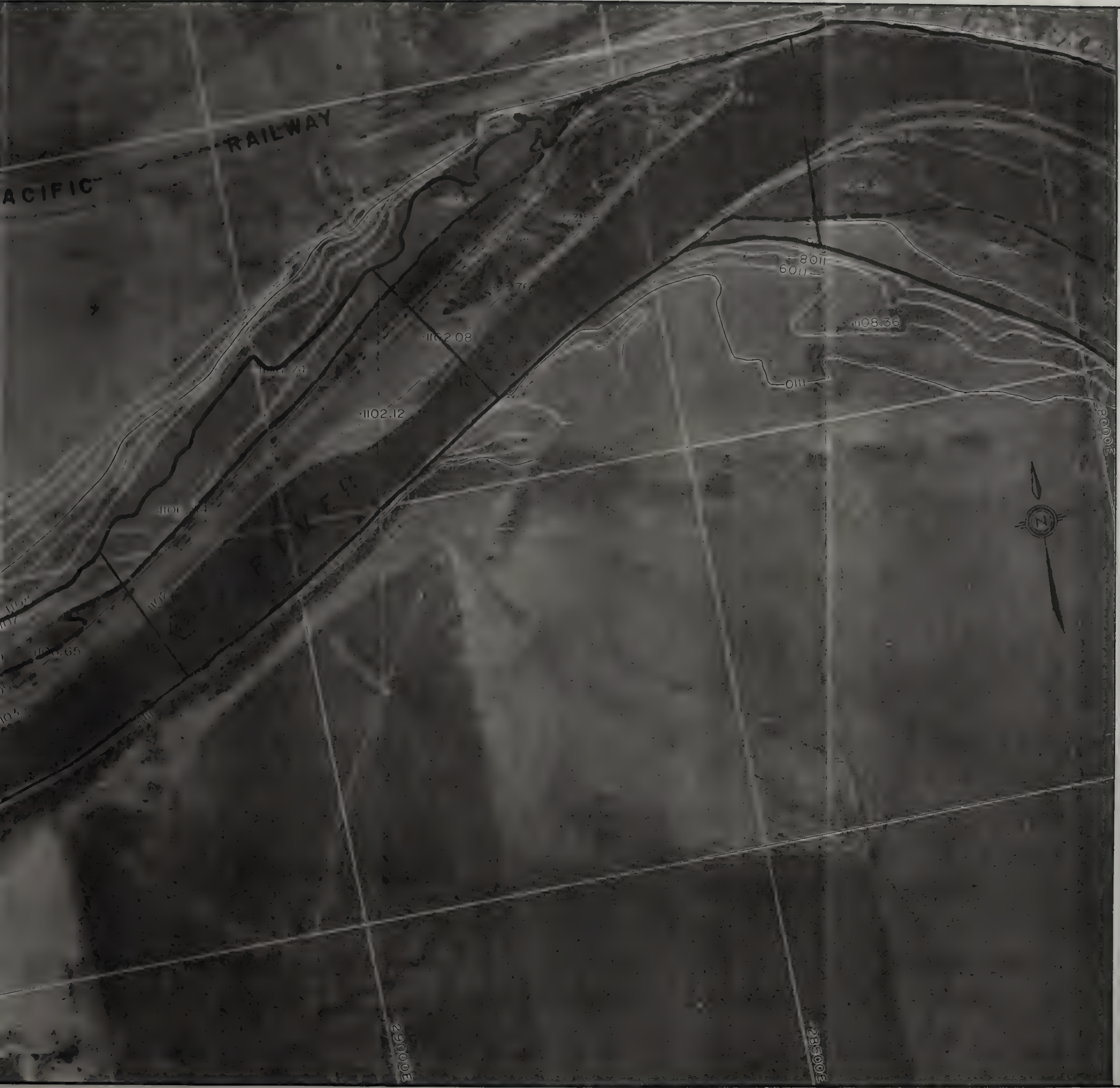


FIGURE 7, SHEET 6

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway — 1:100 Year Flood Risk Area (Ice Hazard Zone)
Flood Fringe

— — — 1:100 Year Open Water Flood Limits

⟨49⟩→ Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

· · · · · · · · · · · Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

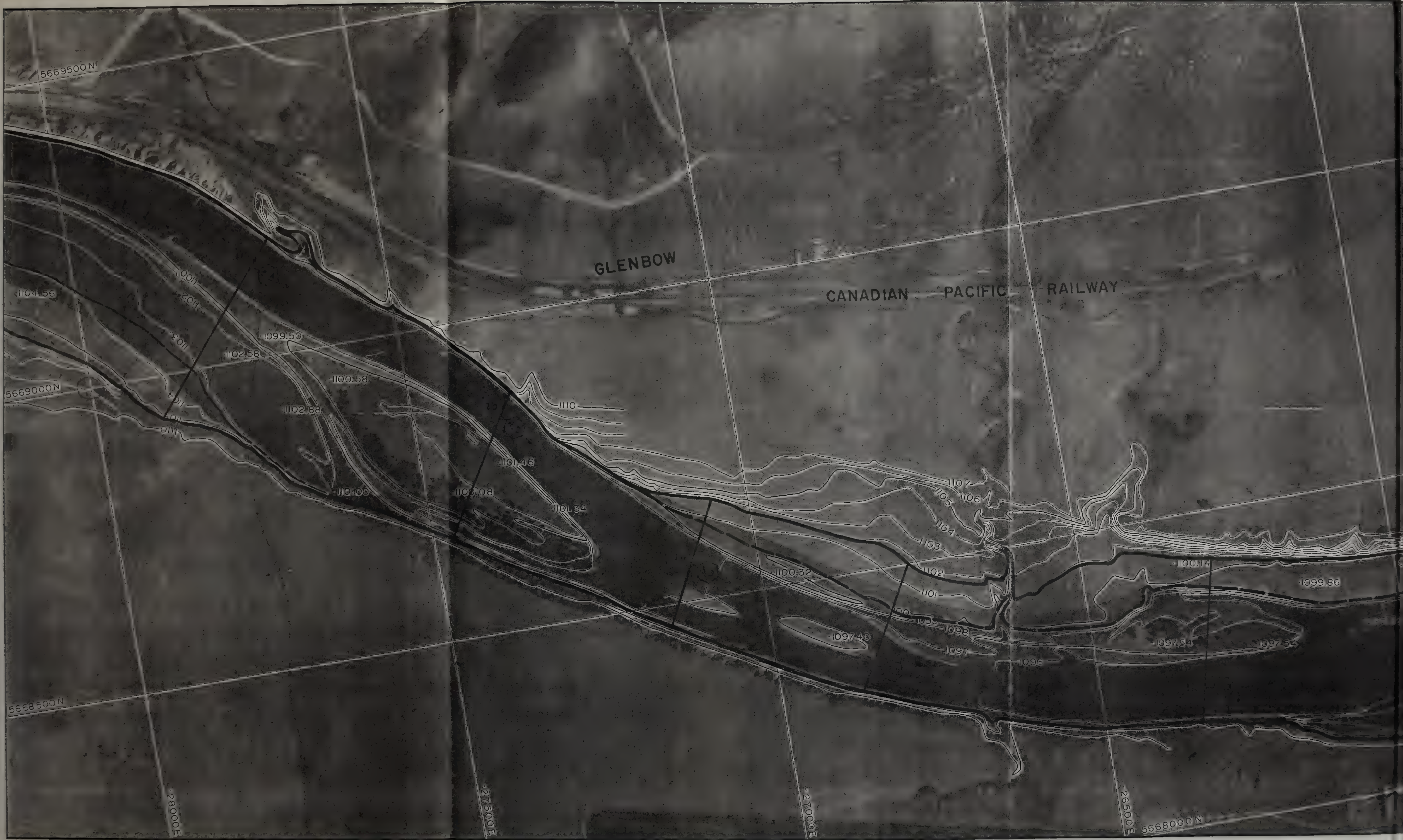
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO	MAY, 1983
CONTOUR INTERVAL	1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada
Environnement Canada


5669500N
5669000N
5668500N
5668000N
28000E
27500E
27000E
26500E
GLENBOW
CANADIAN PACIFIC RAILWAY
1104.56
1100
1101
1103
1099.50
1102.58
1100.58
1102.88
1104
1110
1110
1101.46
1101.00
1100.08
1101.34
1107
1106
1105
1104
1103
1102
1101
1100
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1098
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1096
1100.32
1097.40
1100.14
1099.86
1097.54
1097.53

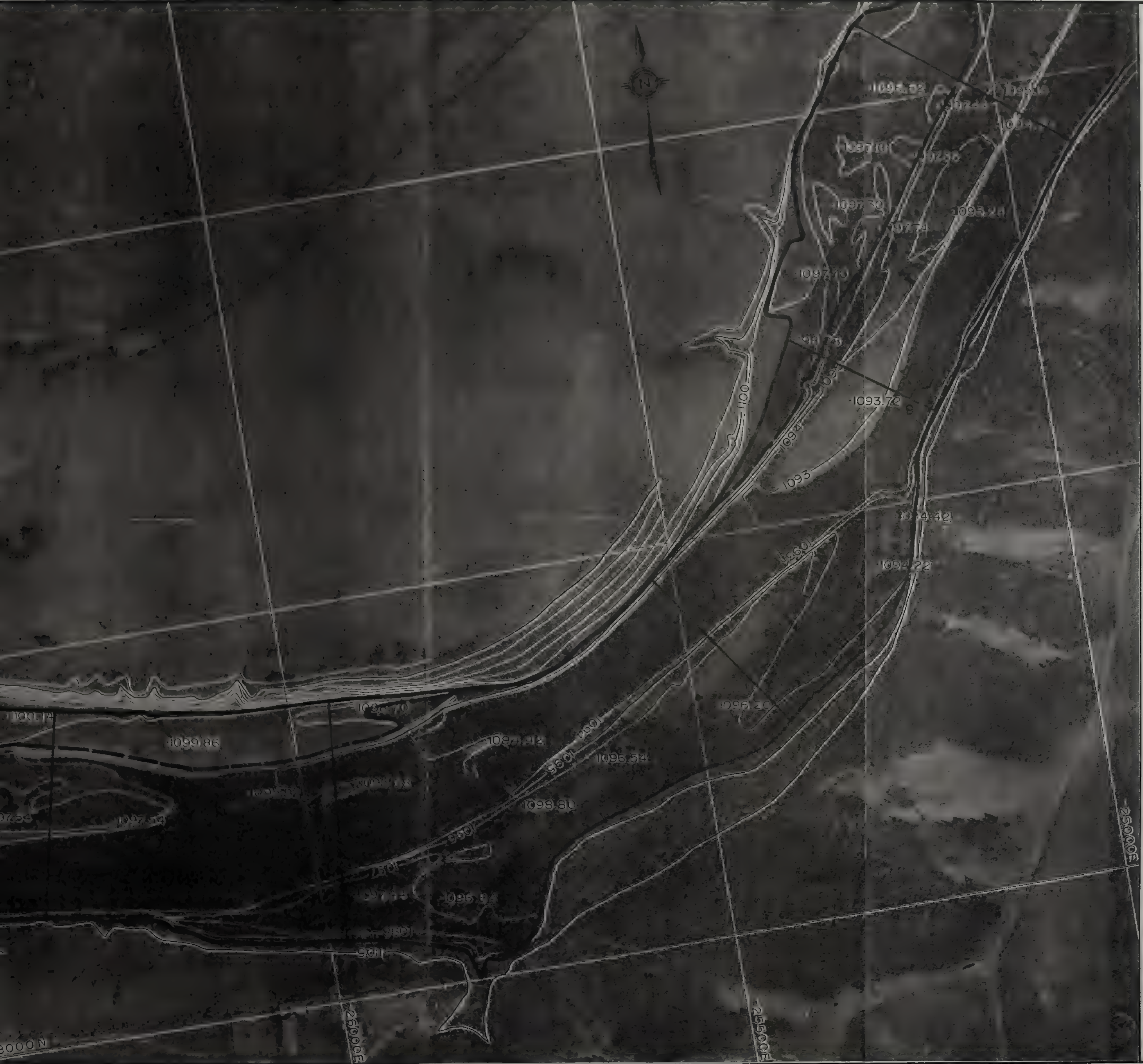


FIGURE 7, SHEET 7

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway
Flood Fringe
1:100 Year Flood Risk Area (Ice Hazard Zone)

1:100 Year Open Water Flood Limits

49 Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

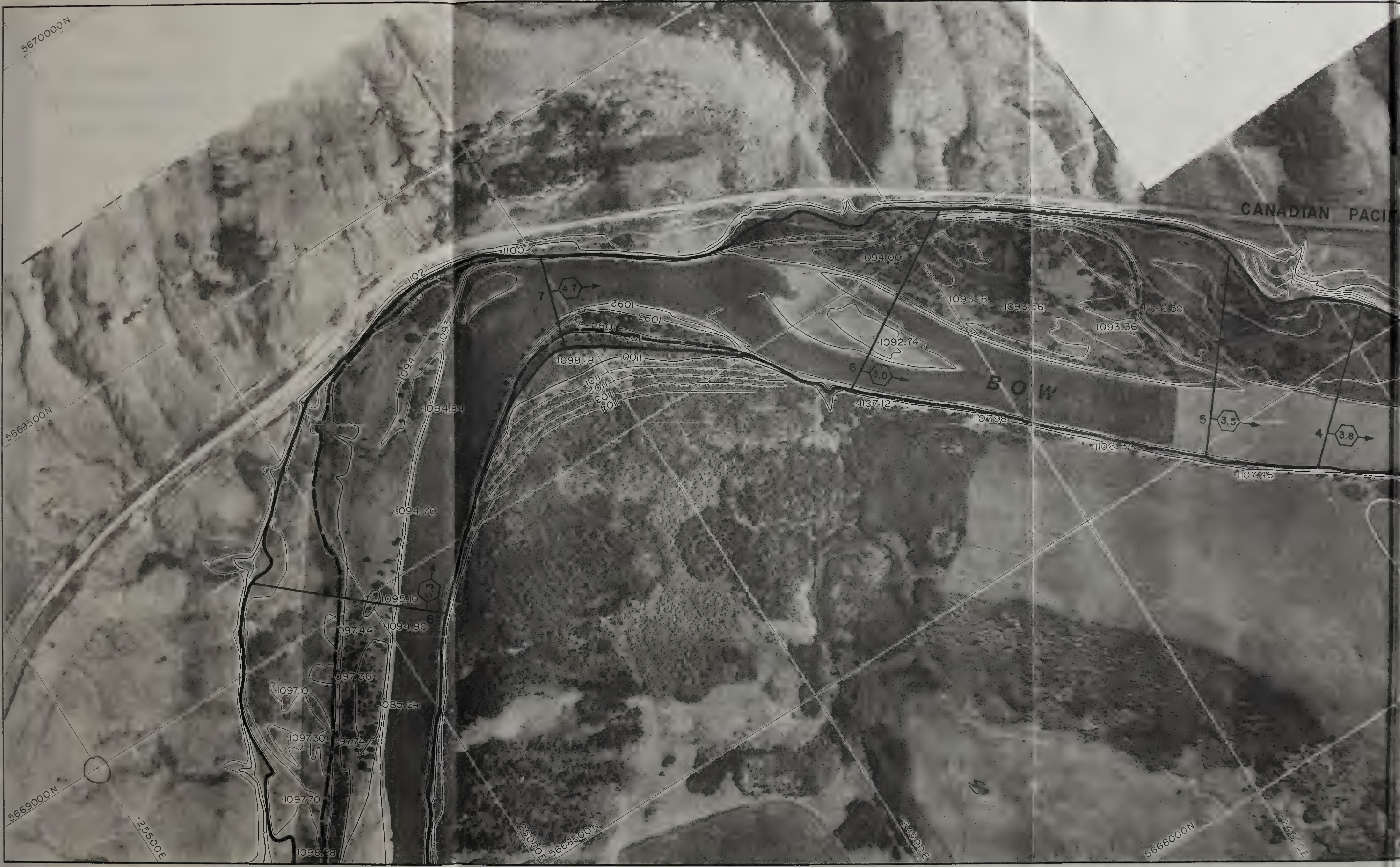
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO MAY, 1983
CONTOUR INTERVAL 1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada Environnement Canada


5670000N
5669500N
5669000N
5668500N
5668000N
25500E
25000E
24500E
CANADIAN PACI
BOW
1100
1102
1094
1093
1094.00
1093.18
1093.56
1092.50
1093.36
1092.74
1092
1093
1094
1098.18
1100
1101
1102
1103
1104
1107.12
1107.98
1108.34
1107.46
1094.84
1094.70
1095.10
1094.90
1097.44
1097.36
1097.10
1085.24
1097.30
1097.74
1097.70
1098.28
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4.7
6
3.0
5
3.5
4
3.8
8
3.3

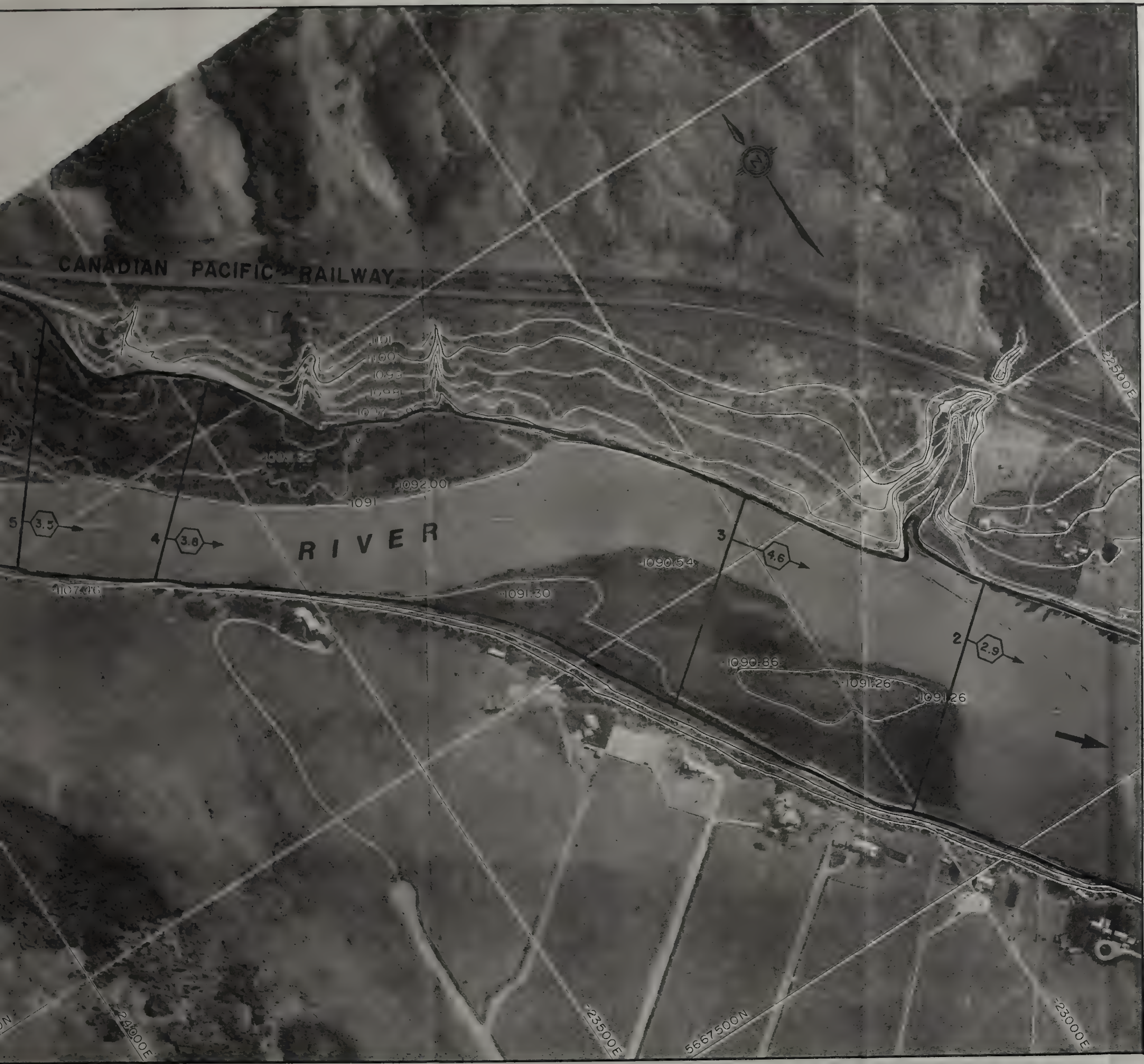


FIGURE 7, SHEET 8

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway
Flood Fringe
1:100 Year Flood Risk Area (Ice Hazard Zone)

— — — — 1:100 Year Open Water Flood Limits

49 → Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

. . . . Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

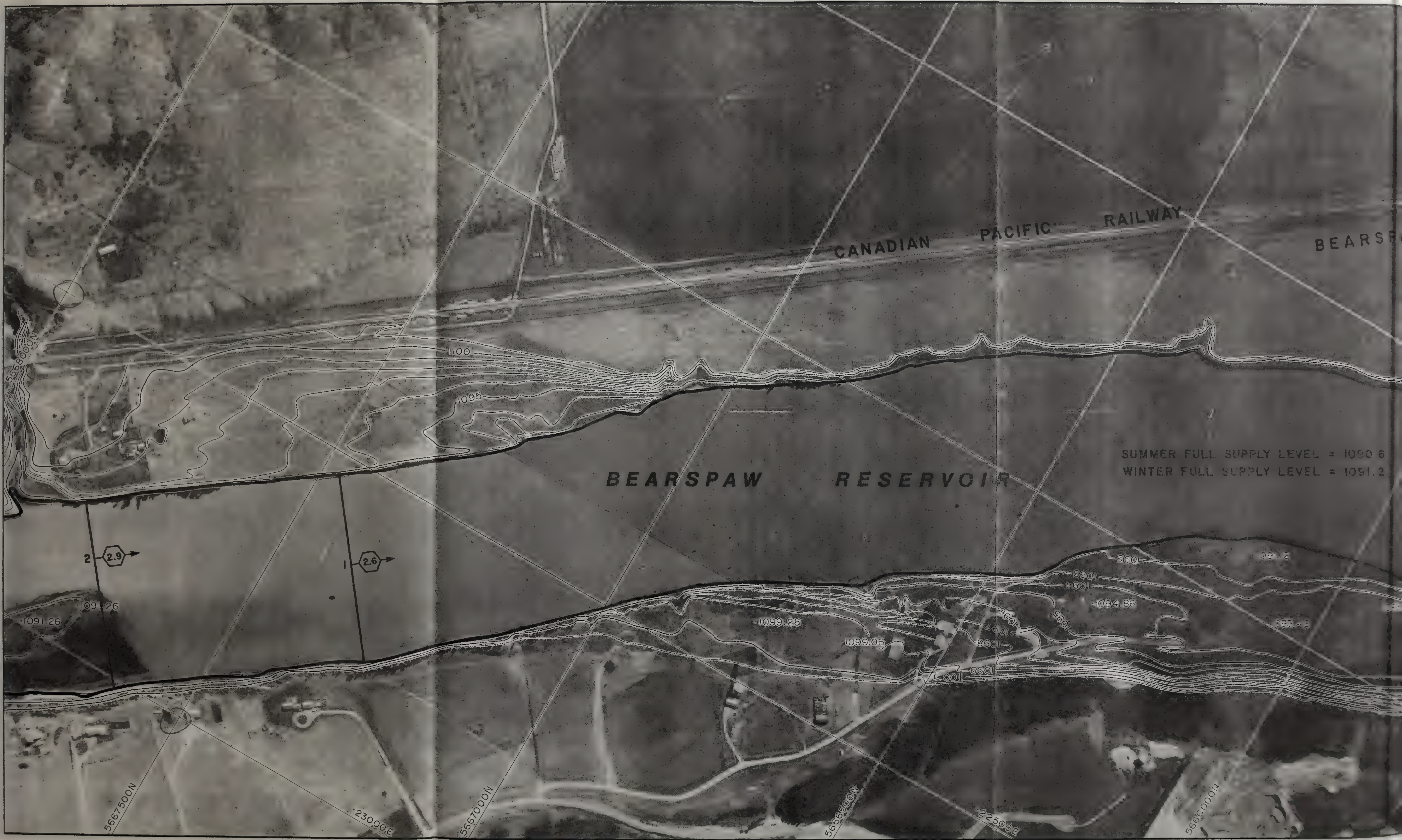
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO	MAY, 1983
CONTOUR INTERVAL	1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada Environnement Canada


CANADIAN PACIFIC RAILWAY
BEARSP
BEARSPAW RESERVOIR
SUMMER FULL SUPPLY LEVEL = 1090.6
WINTER FULL SUPPLY LEVEL = 1091.2
1100
1095
2
2.9
1
2.6
1091.26
1091.26
1099.28
1099.06
1094.86
1092
1093
1094
1095
1096
1097
1098
1099
1100
1091.2
5668000N
5667500N
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5666000N
23000E
22500E

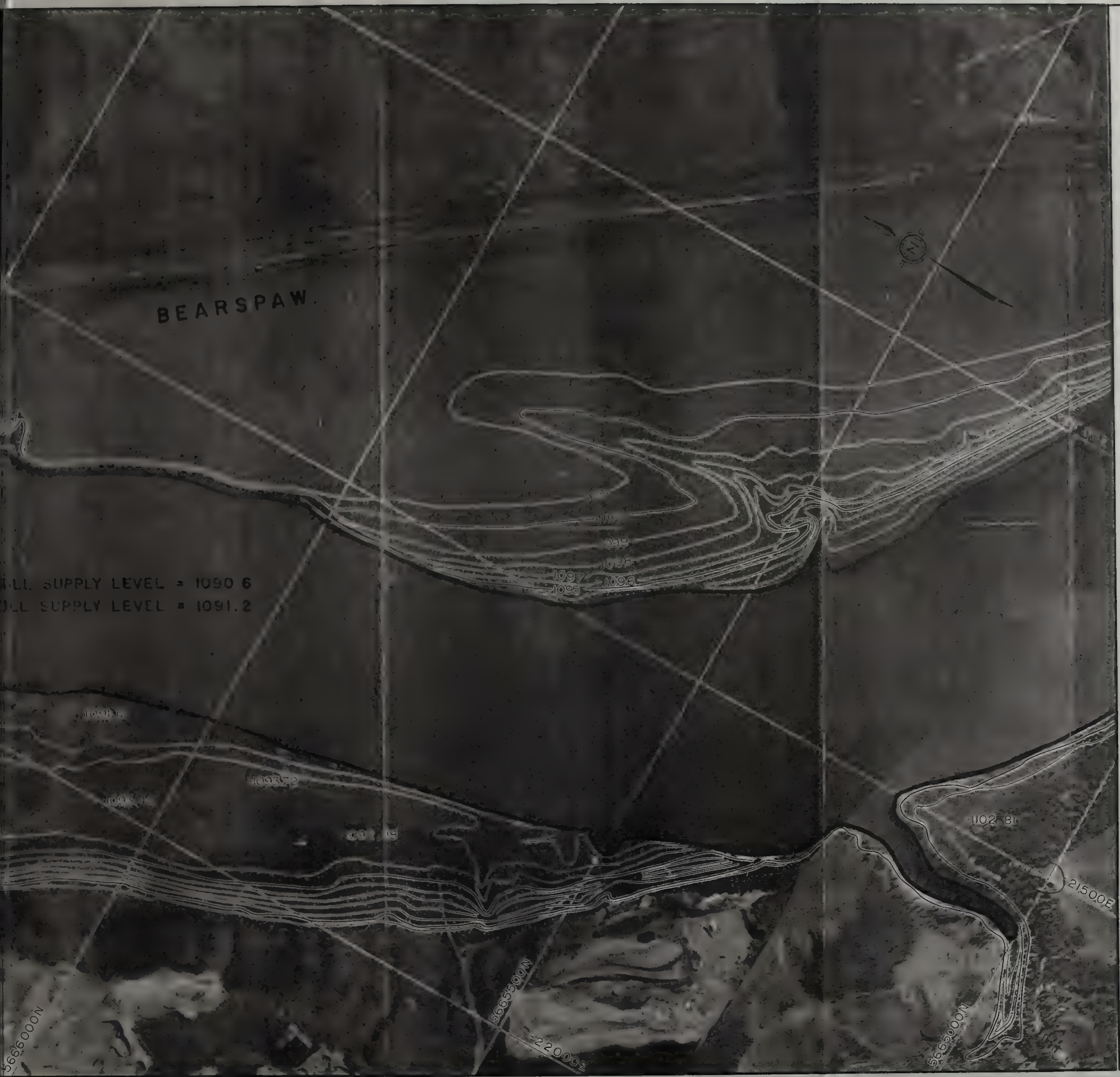


FIGURE 7, SHEET 9

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe
Floodway — 1:100 Year Flood Risk Area (Ice Hazard Zone)
Flood Fringe

— — — — 1:100 Year Open Water Flood Limits

49 → Mean Channel Velocity for a 1:100 Year Open Water Flood

50 Cross - Section Location and Number

. . . . Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

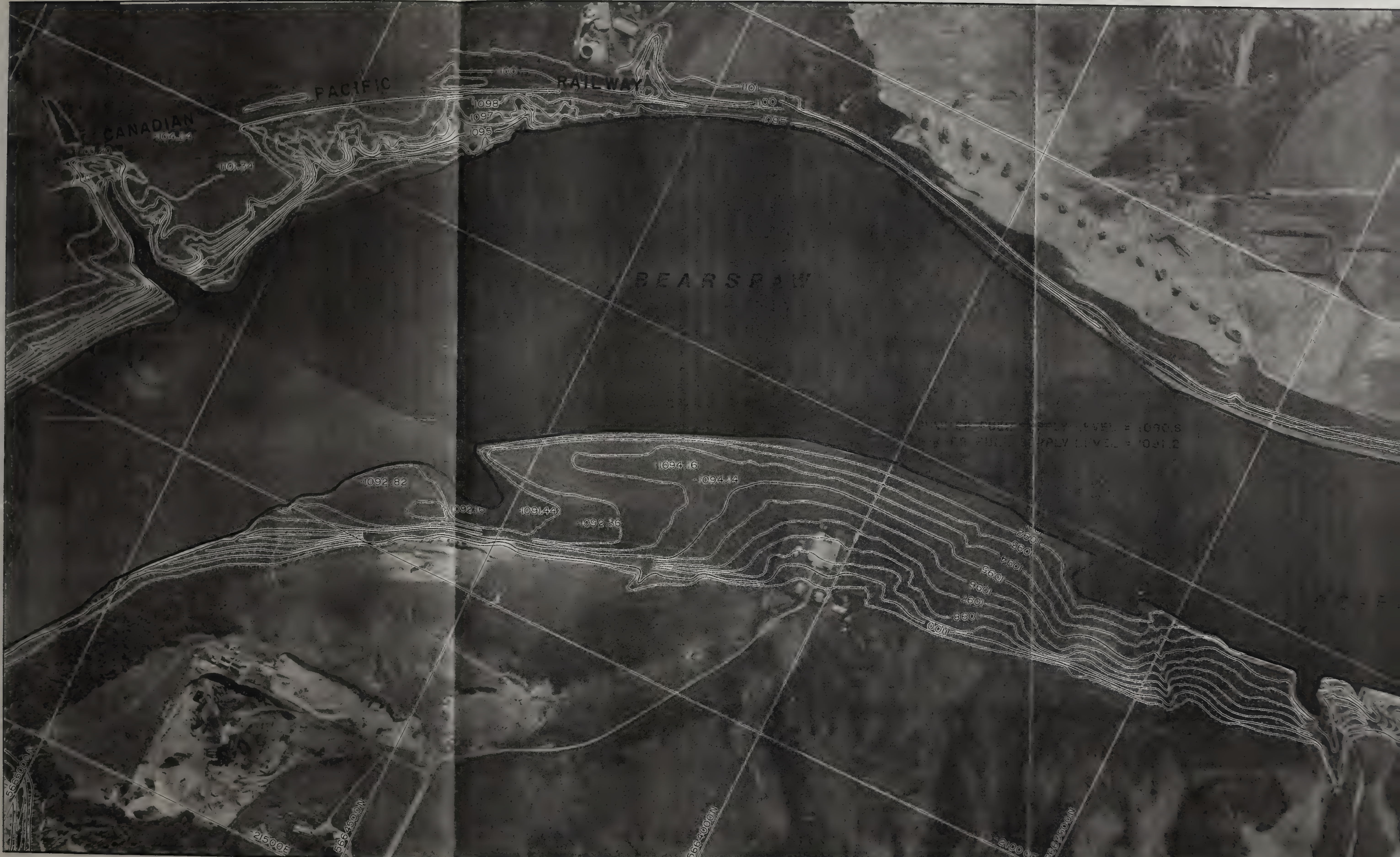
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO	MAY, 1983
CONTOUR INTERVAL	1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada
Environnement Canada


CANADIAN
PACIFIC
RAILWAY
BEARSPAW
1104.24
1103.20
1101.34
1100
1098
1097
1095
1101
1100
1095
FULL SUPPLY LEVEL = 1090.5
FULL SUPPLY LEVEL = 1091.2
1094.16
1094.14
1092.82
1092.18
1091.44
1092.36
1098
1096
1094
1095
1096
1095
1097
1098
1100
5665000N
5664500N
5664000N
5663500N
2500E
2100E

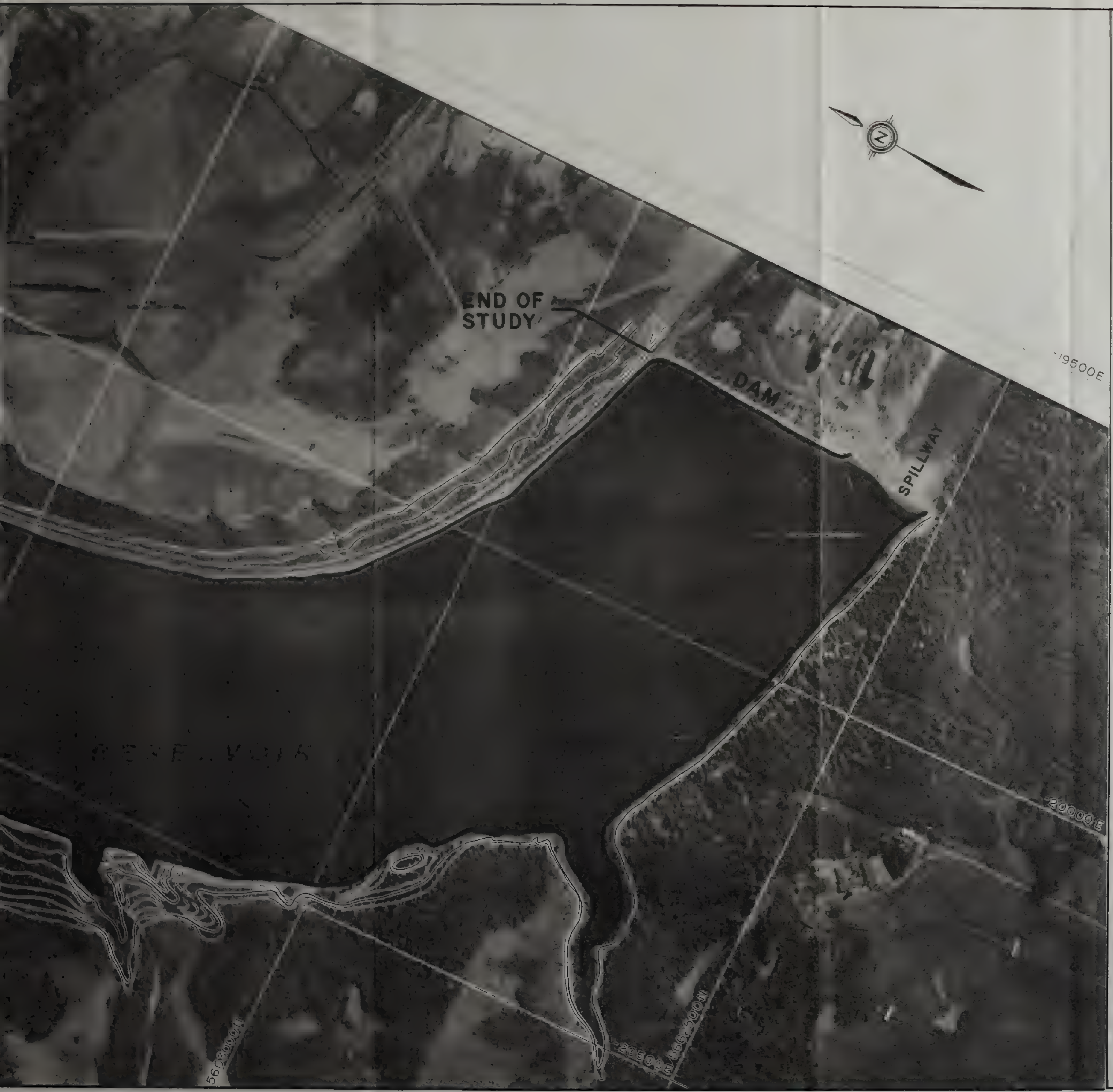


FIGURE 7, SHEET 10

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bow River)

REVISED: NOVEMBER, 1990

LEGEND

Flood Fringe Floodway Flood Fringe		1:100 Year Flood Risk Area (Ice Hazard Zone)
— — — —		1:100 Year Open Water Flood Limits
⟨49⟩→		Mean Channel Velocity for a 1:100 Year Open Water Flood
50		Cross - Section Location and Number
··············		Town of Cochrane Corporate Limits

SCALE 1 : 5 000

0 100 200 300 400 500 M

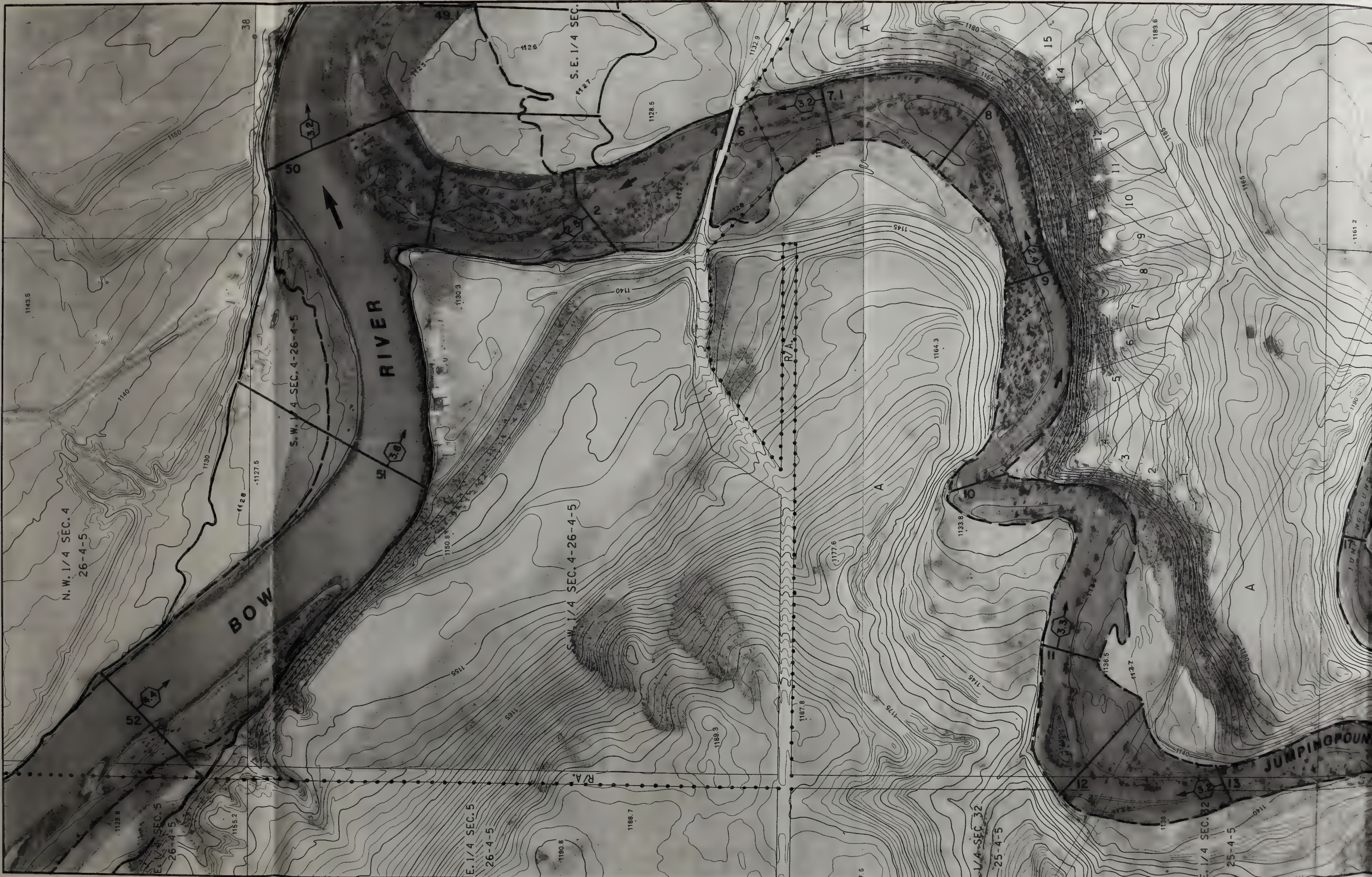
* BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1984

ORTHOPHOTO	MAY, 1983
CONTOUR INTERVAL	1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada — Environnement Canada


BOW RIVER
JUMPINGPOUND
N.W. 1/4 SEC. 4
26-4-5
S.W. 1/4 SEC. 4-26-4-5
S.W. 1/4 SEC. 4-26-4-5
S.E. 1/4 SEC.
E. 1/4 SEC. 5
26-4-5
1/4 SEC. 32
25-4-5
E. 1/4 SEC. 32
25-4-5
R/A
R/A
A
A
A
49
50
51
52
3.2
3.6
4.4
2.5
3.2
7.1
4.2
3.3
3.8
1143.5
1150
1140
1130
1127.5
1128
1126
1125
1127
1128.5
1132.9
1130.3
1150.8
1145
1155
1165
1164.3
1177.6
1187.8
1189.3
1188.7
1190.8
1155.2
1128.8
1133.8
1136.5
1180
1189.6
1161.2
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3
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11
12
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14
15

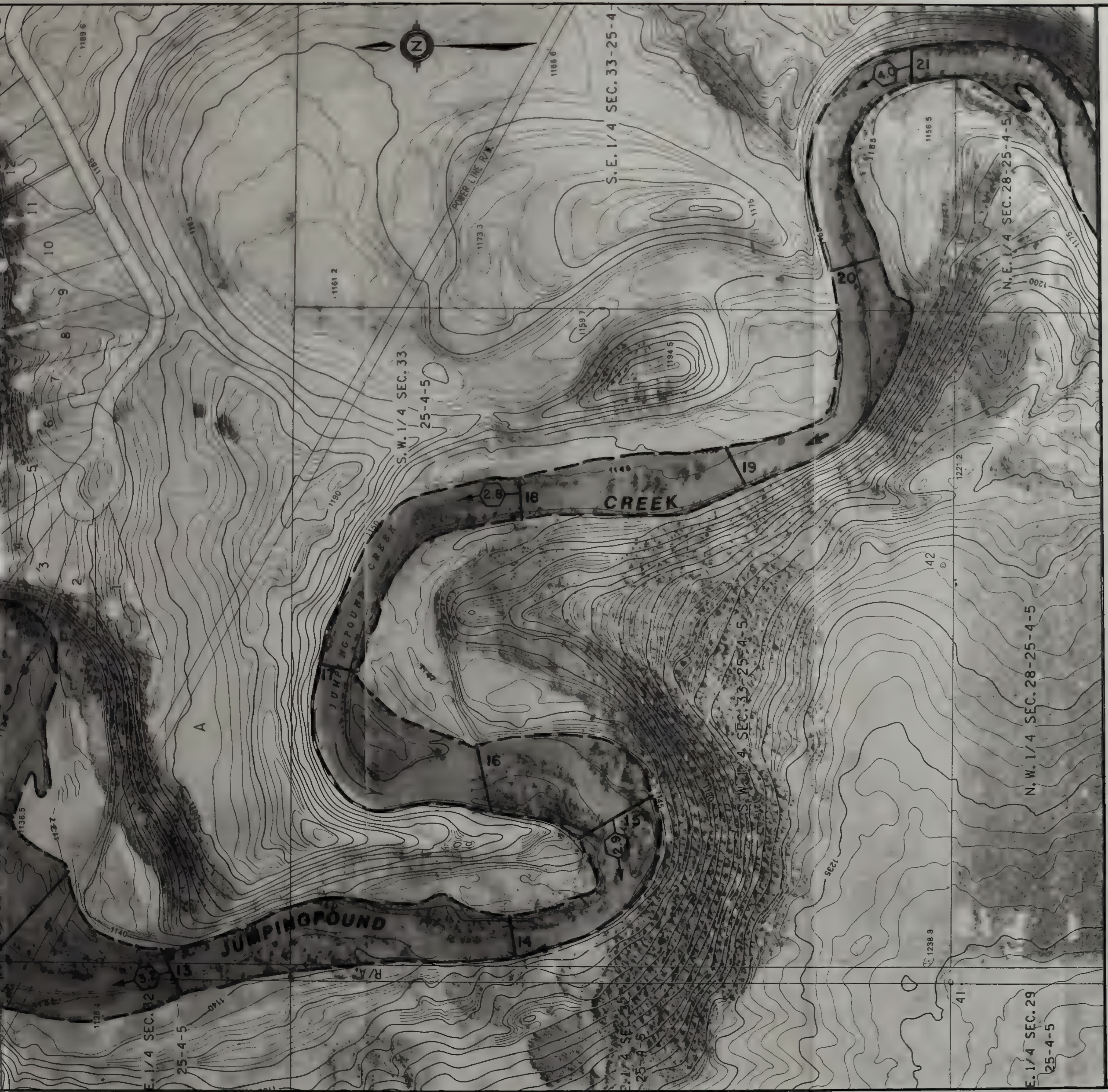


FIGURE 7, SHEET 11

FLOOD RISK MAP
COCHRANE, ALBERTA
(Jumpingpound Creek)

REVISED: NOVEMBER, 1990

LEGEND

Floodway — 1:100 Year Flood Risk Area * (Open Water Flooding)

3.3 — Mean Channel Velocity for a 1:100 Year Open Water Flood

50 — Cross - Section Location and Number

. . . . — Town of Cochrane Corporate Limits

* Jumpingpound Creek has been designated as a one-zone flood risk area (i.e. the entire flood risk area should be treated as floodway)

SCALE 1 : 5 000

0 100 200 300 400 500 M

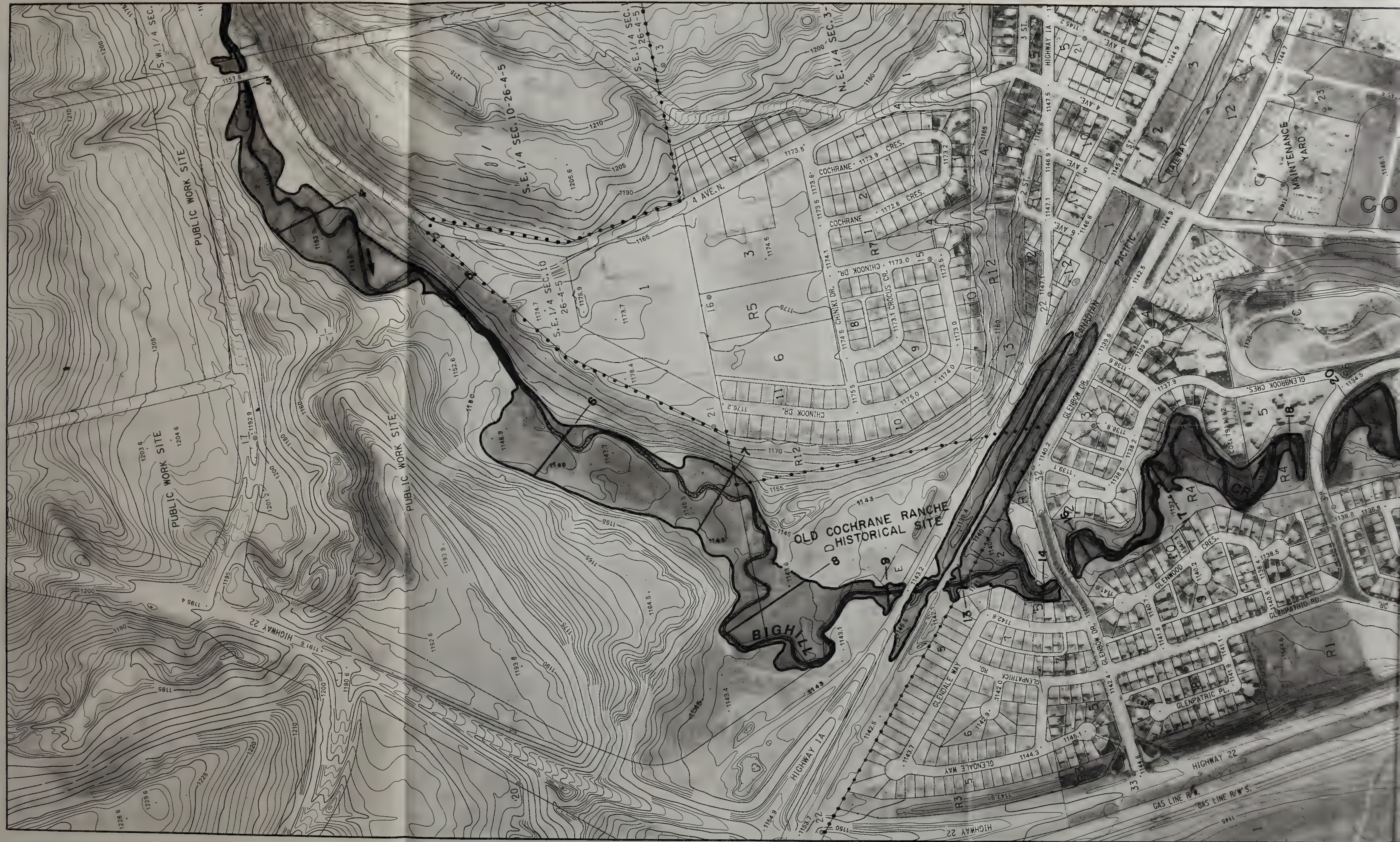
• BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1982

ORTHOPHOTO . . . . MAY, 1981
CONTOUR INTERVAL . . . . 1.0 metre

Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

Alberta
ENVIRONMENT

Environment Canada
Environnement Canada


S.W. 1/4 SEC.
S.E. 1/4 SEC. 10-26-4-5
S.E. 1/4 SEC. 10 26-4-5
S.E. 1/4 SEC. 26-4-5
N.E. 1/4 SEC. 3-
PUBLIC WORK SITE
PUBLIC WORK SITE
PUBLIC WORK SITE
4 AVE. N.
COCHRANE CRES.
COCHRANE CRES.
CHINOOK DR.
CHINOOK DR.
CROCUS CR.
CHINIKI DR.
OLD COCHRANE RANCHE HISTORICAL SITE
BIGHILL CR.
CR.
HIGHWAY 22
HIGHWAY 22
HIGHWAY 22
HIGHWAY 1A
HIGHWAY 1A
CANADIAN PACIFIC RAILWAY
3 ST.
2 ST.
1 ST.
3 AVE.
4 AVE.
5 AVE.
6 AVE.
GLENBOW DR.
GLENBOW DR.
GLENBROOK CRES.
GLENWOOD CRES.
GLENPATRICK RD.
GLENPATRICK RD.
GLENPATRICK PL.
GLENDALE WAY
GLENDALE WAY
MAINTENANCE YARD
GAS LINE R/W.
GAS LINE R/W S.
R12
R12
R5
R7
R4
R4
R1
R3
CO

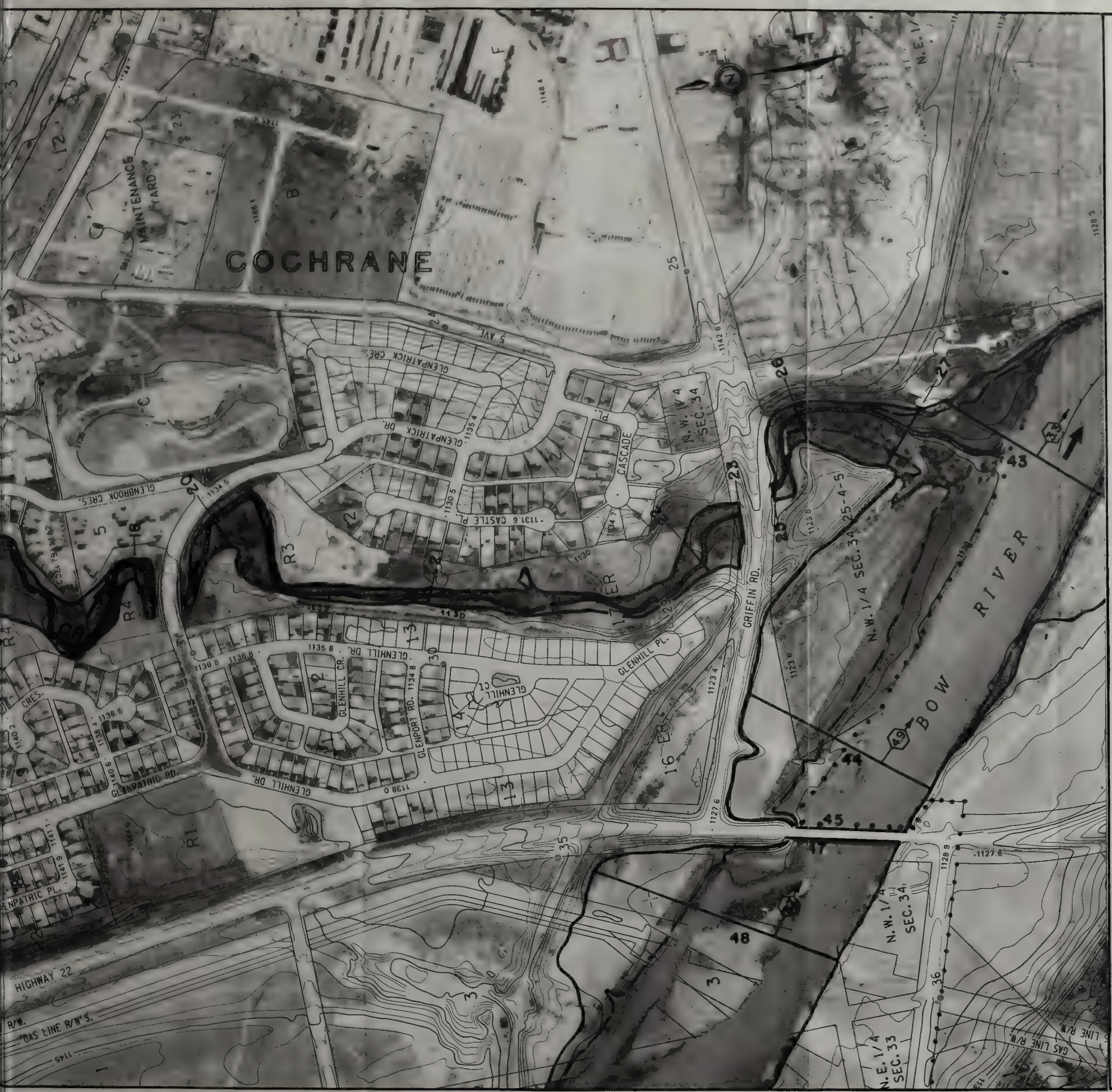


FIGURE 7, SHEET 12

FLOOD RISK MAP
COCHRANE, ALBERTA
(Bighill Creek)

REVISED: NOVEMBER, 1990

LEGEND

Floodway	1:100 Year Flood Risk Area * (Open Water and Ice Hazard Flood Zone)
20	Cross - Section Location and Number
....	Town of Cochrane Corporate Limits

* Bighill Creek has been designated as a one-zone flood risk area.
(i.e. the entire flood risk area should be treated as floodway)

SCALE 1 : 5 000

0 100 200 300 400 500 M

• BASE MAPPING PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING, 1982

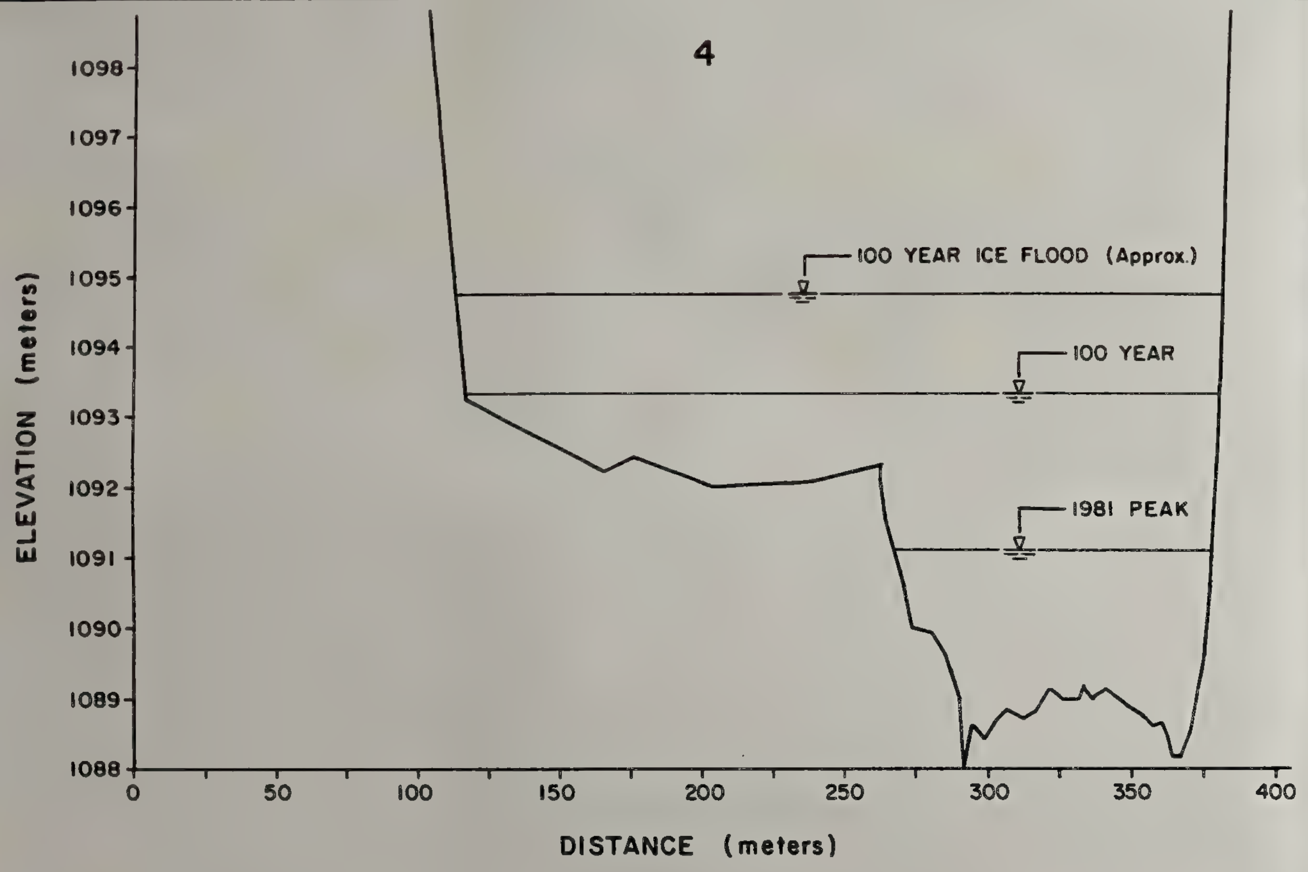
ORTHOPHOTO .... MAY, 1981
CONTOUR INTERVAL .... 1.0 metre

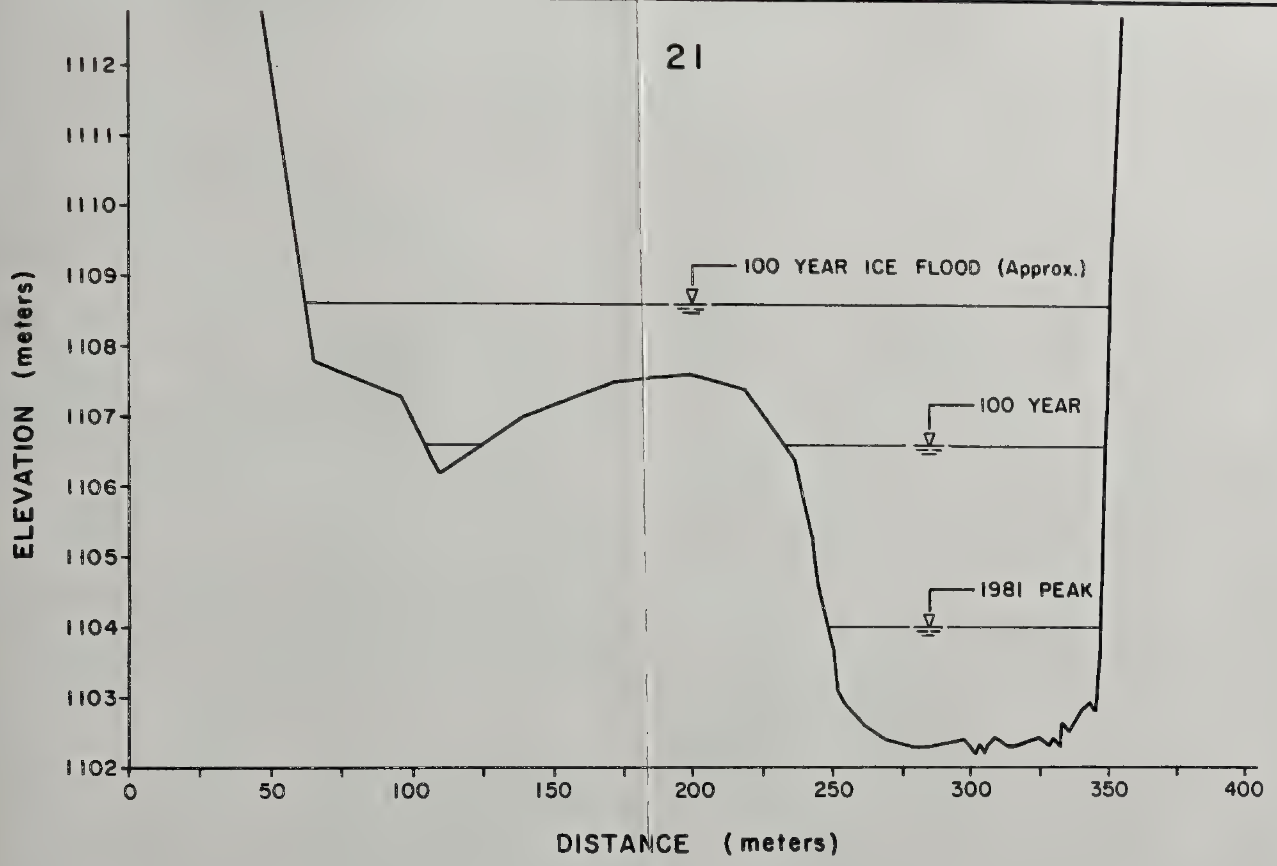
Canada-Alberta
FLOOD
DAMAGE
REDUCTION
PROGRAM

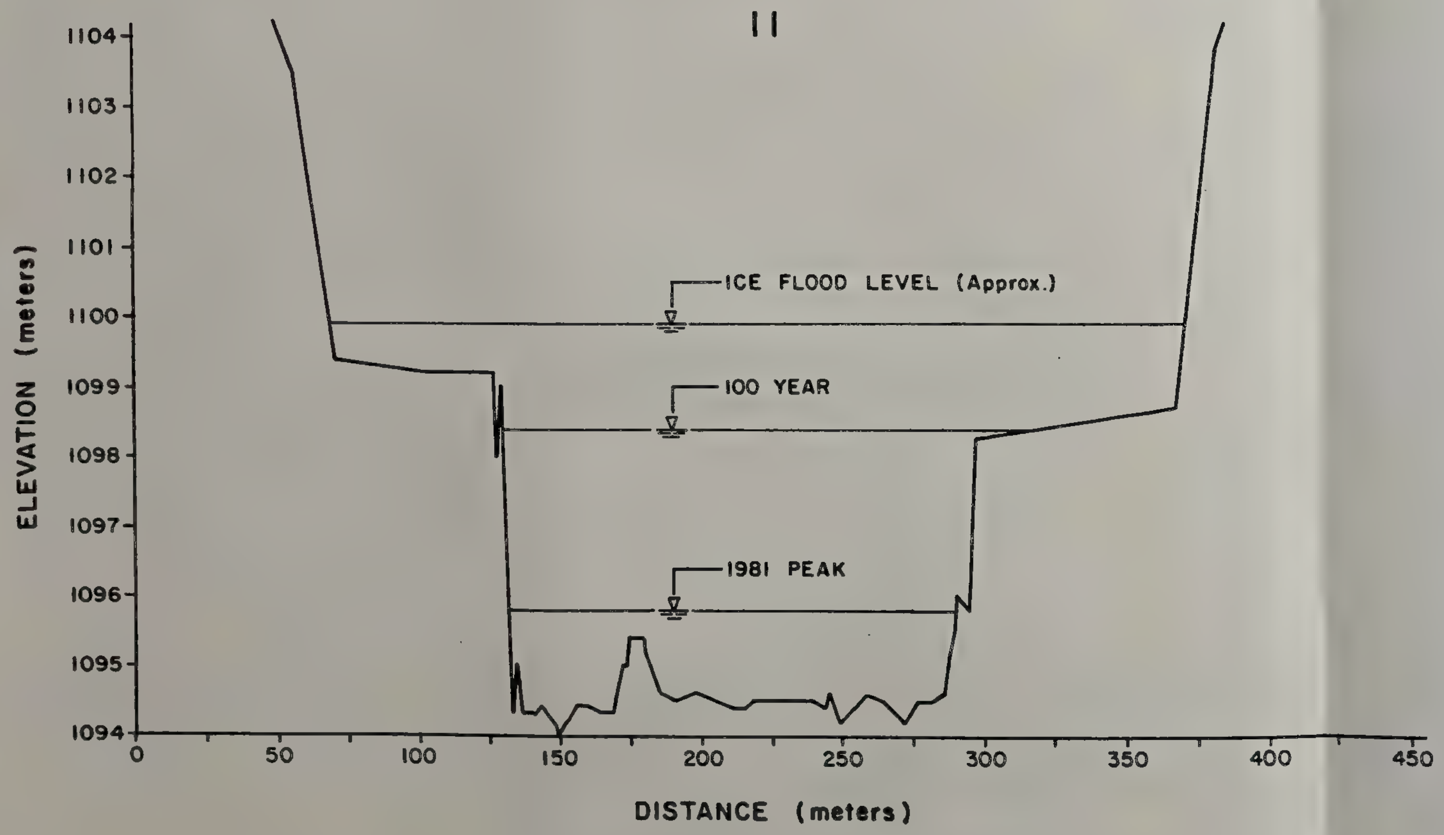
Alberta
ENVIRONMENT

Environment Canada
Environnement Canada

APPENDIX A
Representative Cross Sections







NOTE : CROSS-SECTIONS ARE PLOTTED FROM LEFT BANK TO RIGHT BANK LOOKING DOWNSTREAM.

SCALE — VERT. 1:100
HORIZ. 1:2500

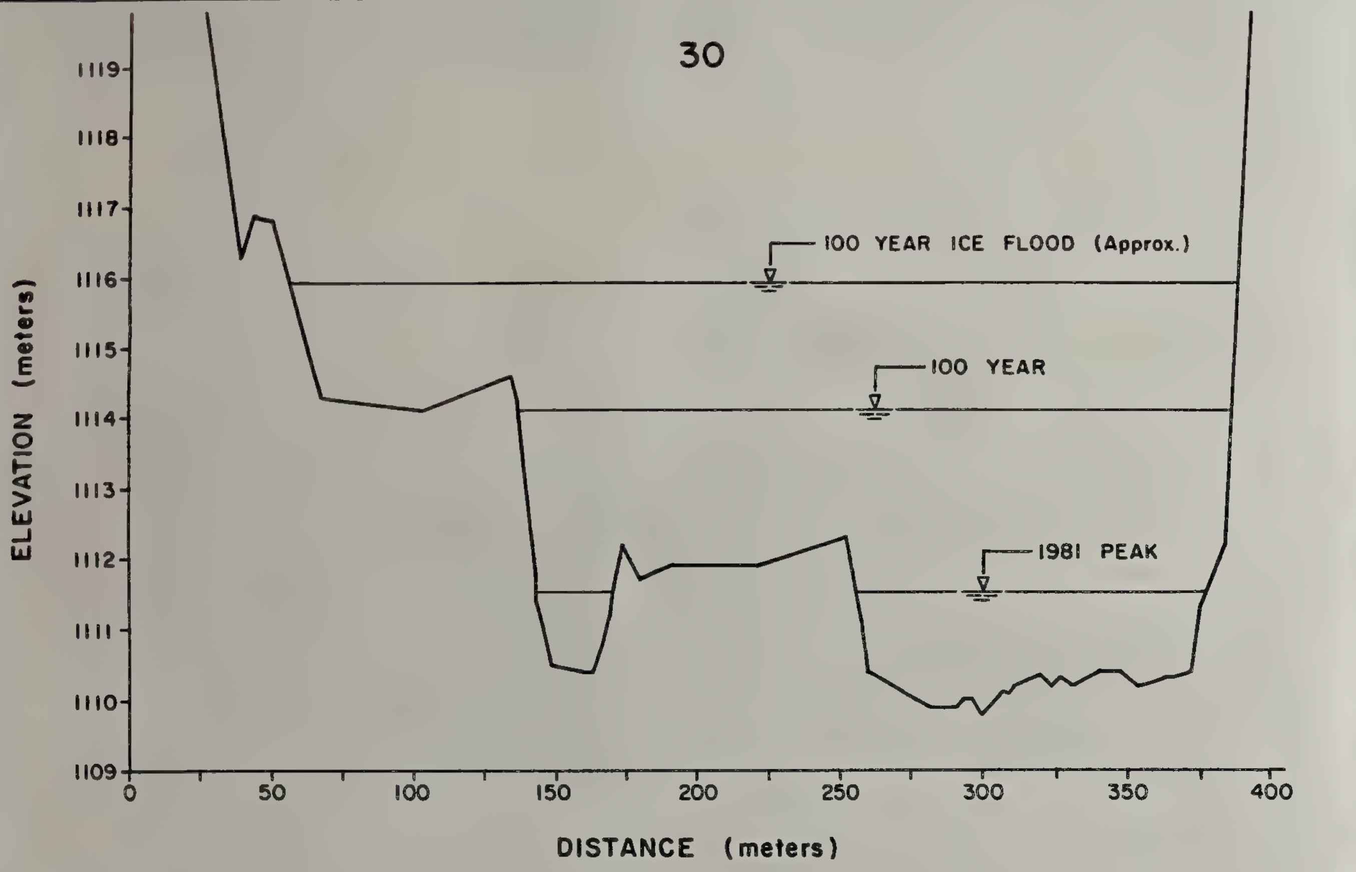
Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division

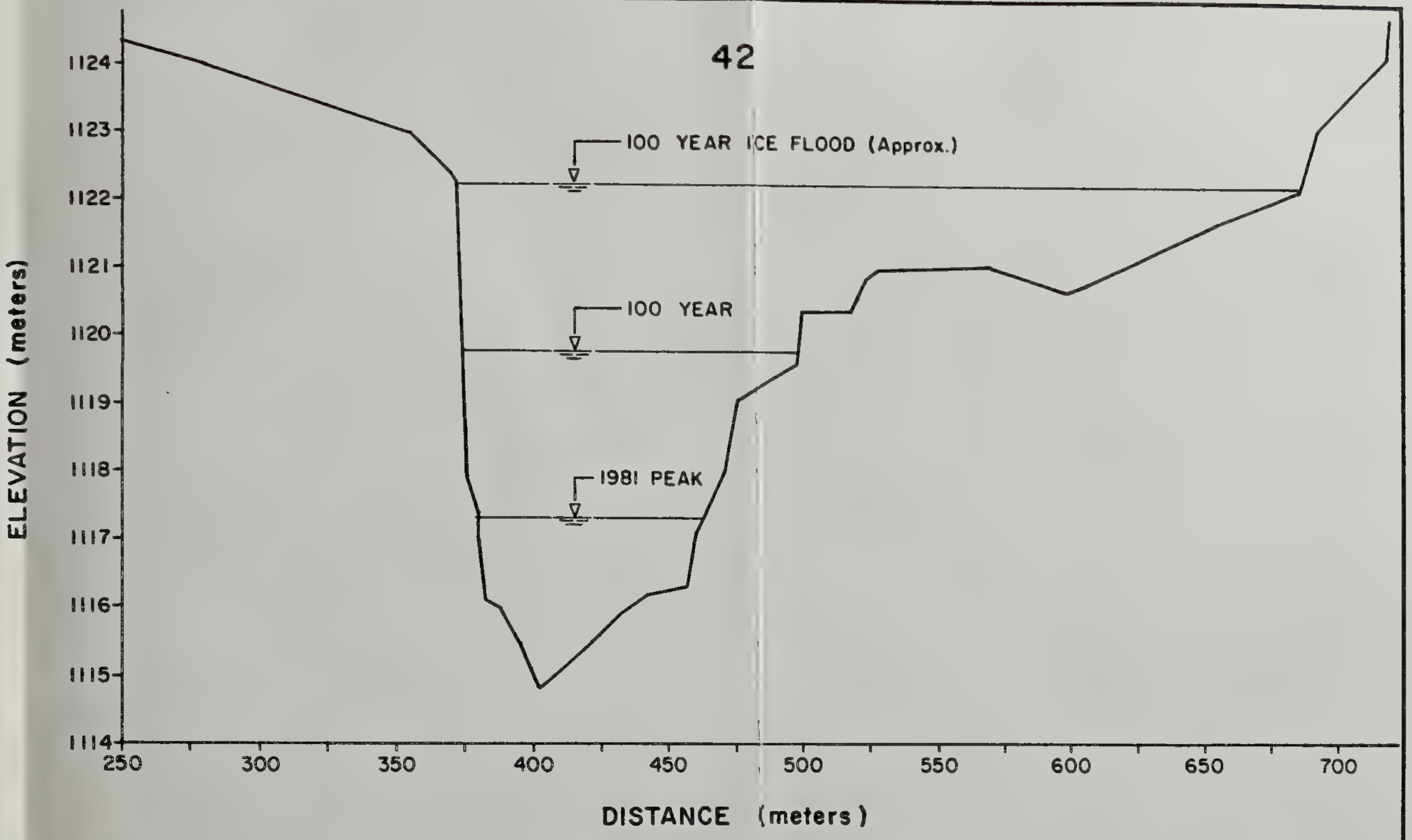
COCHRANE FLOODPLAIN STUDY

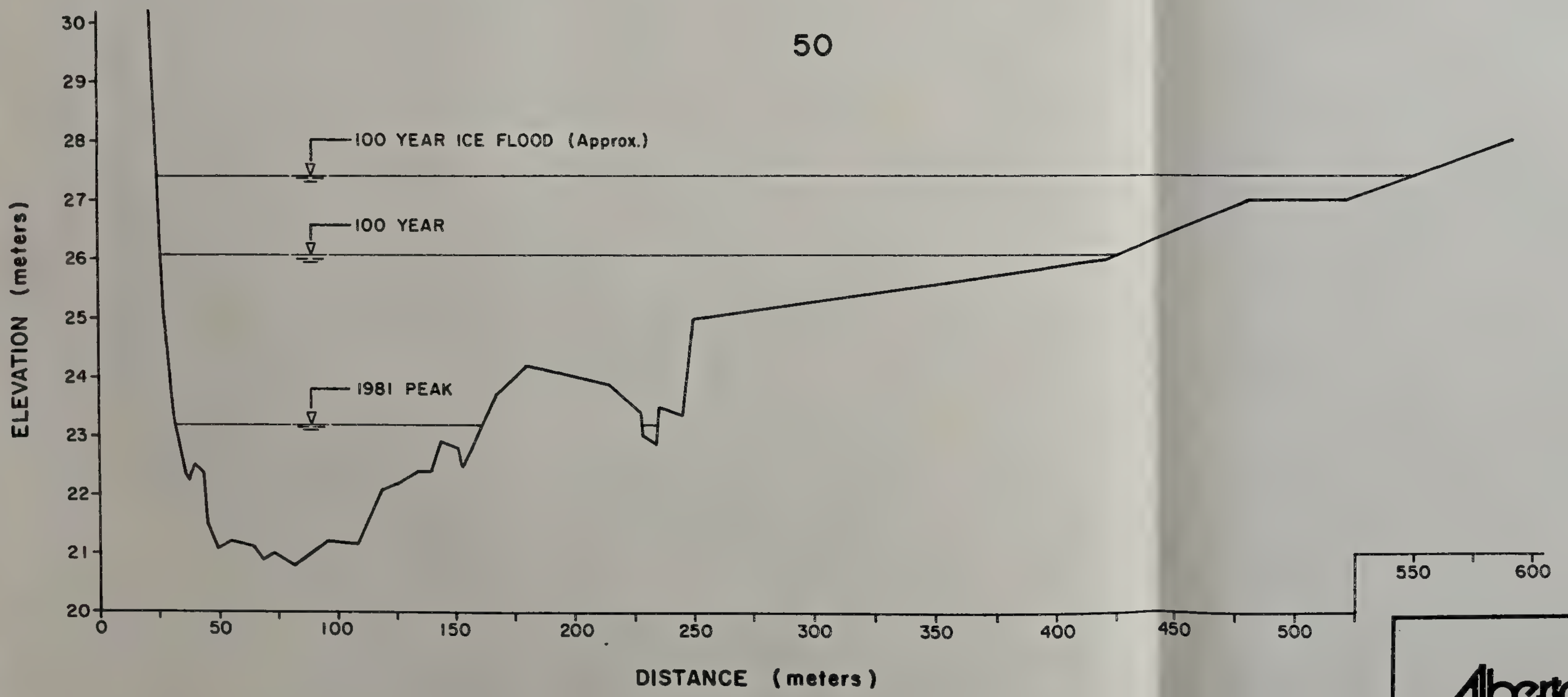
REPRESENTATIVE CROSS - SECTIONS
BOW RIVER

DRAWN BY : M.G.M.
APPROVED BY : M. Chuaz
FIGURE NO. A-1
CHECKED BY : T. Windhold
DATE : June 17/86
SHEET 1 OF 4

P3-280 x 430







NOTE : CROSS-SECTIONS ARE PLOTTED FROM LEFT BANK TO RIGHT BANK LOOKING DOWNSTREAM.

SCALE – VERT. 1:100
HORIZ. 1:2500

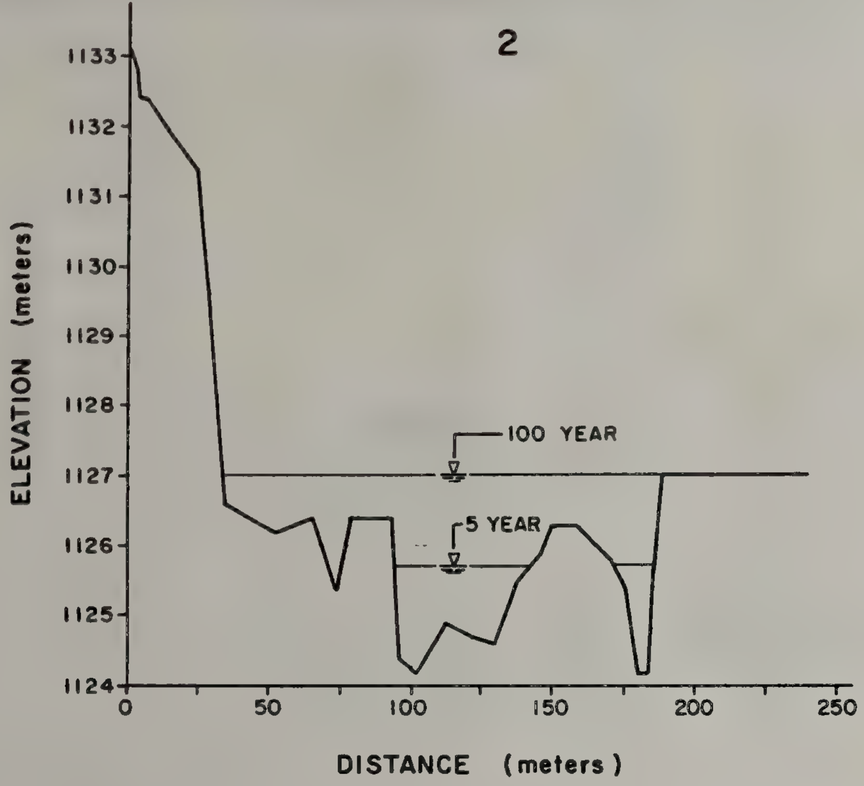
Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division

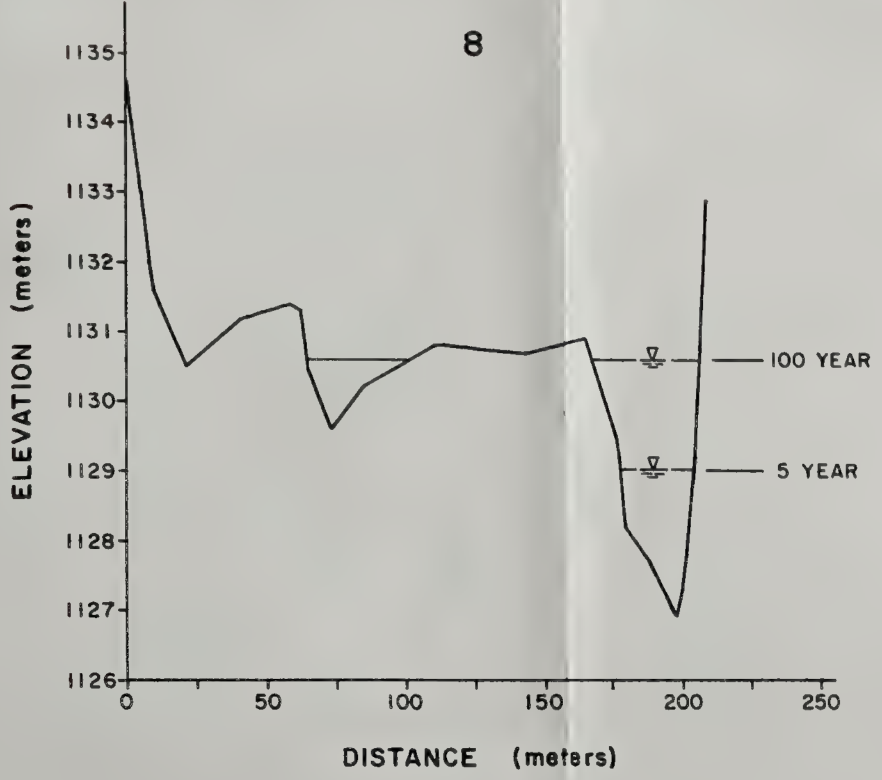
COCHRANE FLOODPLAIN STUDY

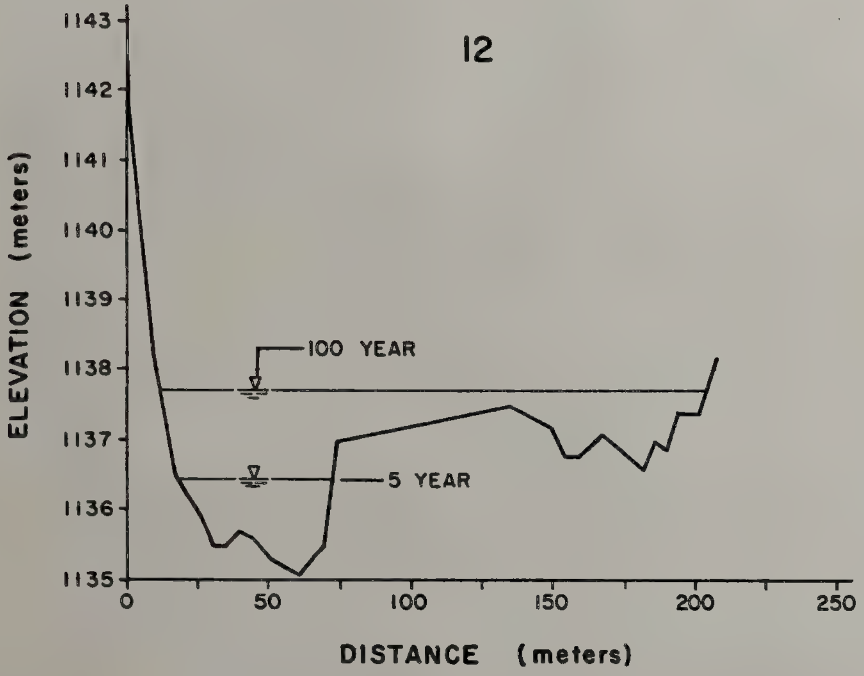
REPRESENTATIVE CROSS-SECTIONS
BOW RIVER

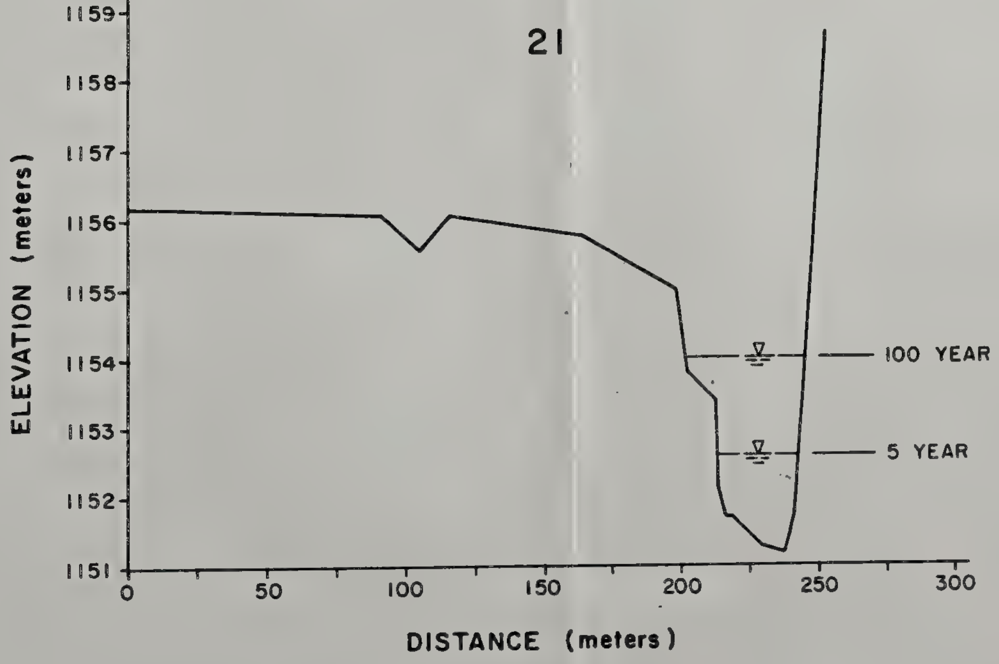
DRAWN BY : M.G.M.
APPROVED BY :
FIGURE NO. A-2
CHECKED BY :
DATE June 17/86
SHEET 2 OF 4

P3-280 x 430









NOTE : CROSS-SECTIONS ARE PLOTTED FROM LEFT BANK TO RIGHT BANK LOOKING DOWNSTREAM.

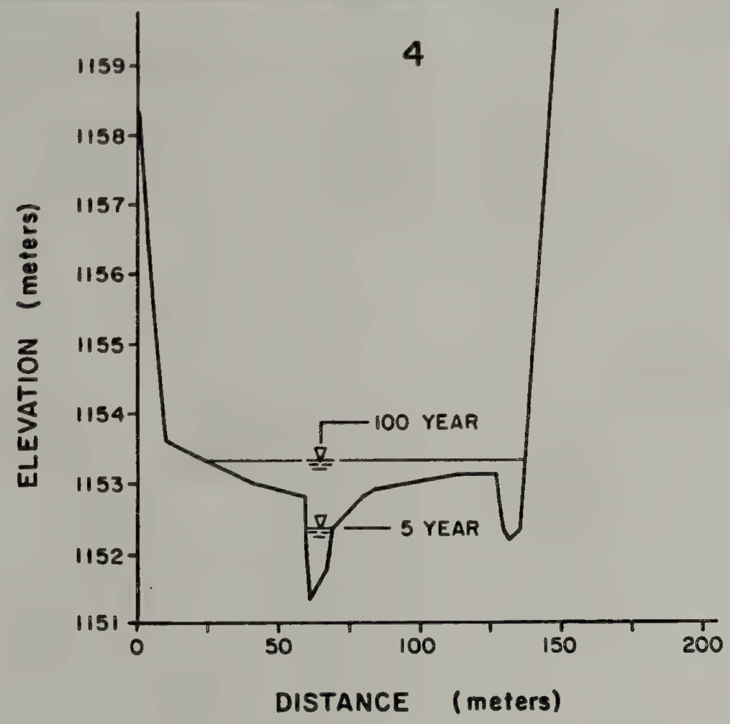
SCALE - VERT. 1:100
HORIZ. 1:2500

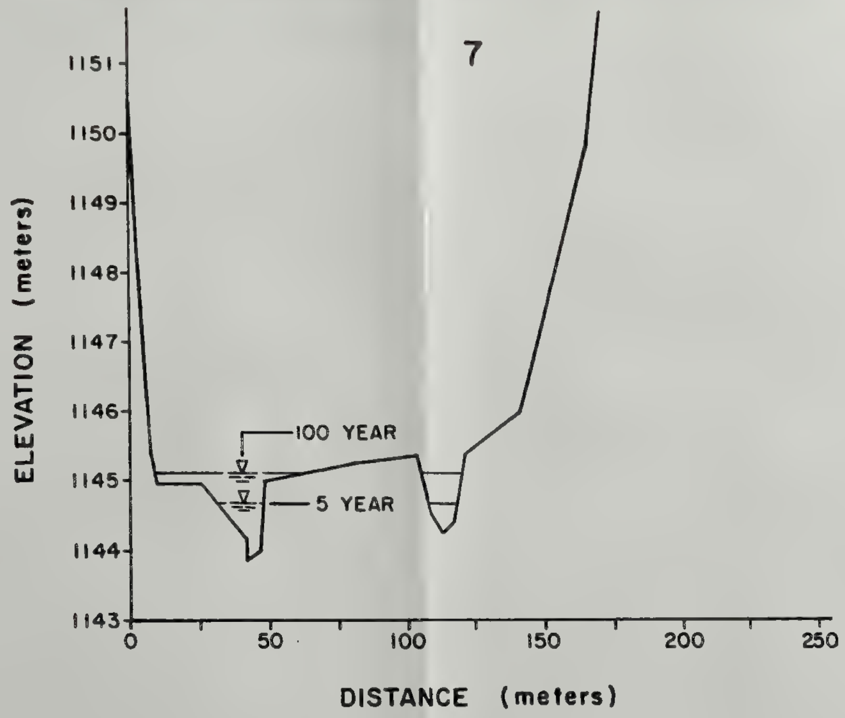
Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division

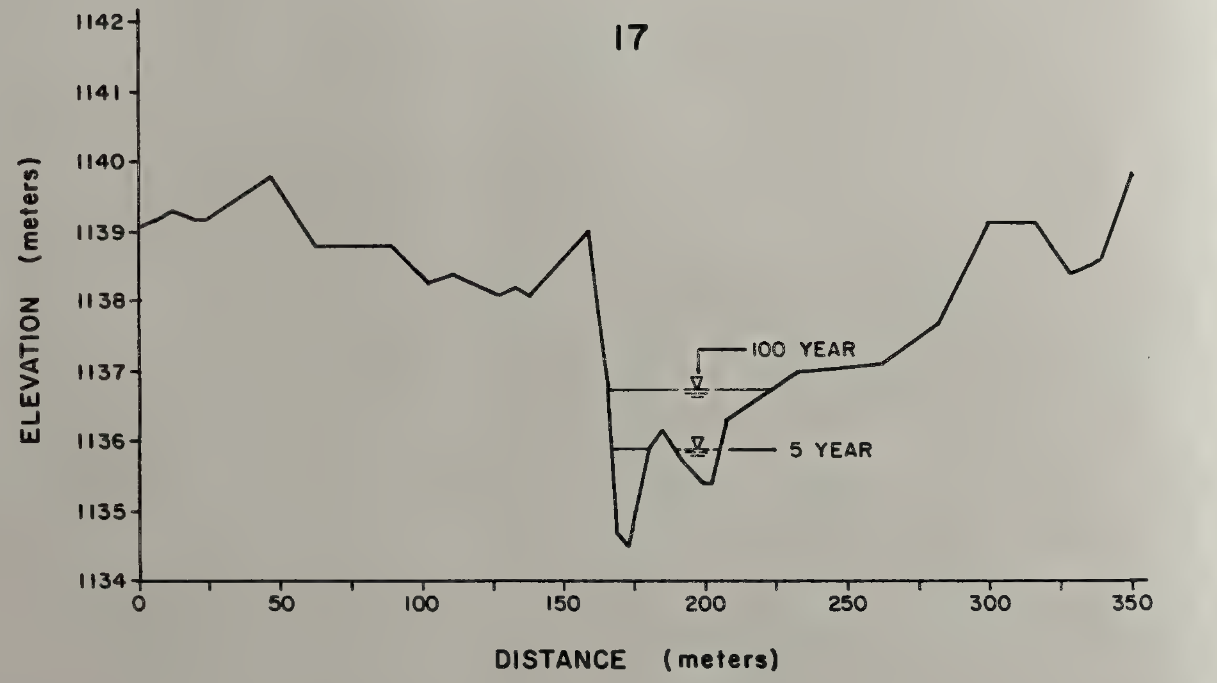
COCHRANE FLOODPLAIN STUDY

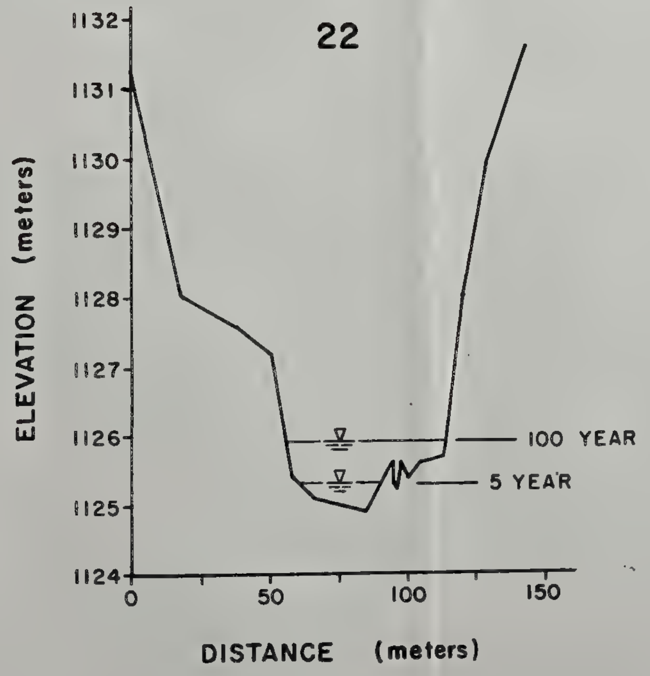
REPRESENTATIVE CROSS-SECTIONS
JUMPING POUND CREEK

DRAWN BY : M.G.M.
APPROVED BY :
FIGURE NO. A-3
CHECKED BY: T.Waibold
DATE : June 17/86
SHEET 3 OF 4









NOTE : CROSS-SECTIONS ARE PLOTTED FROM LEFT BANK TO RIGHT BANK LOOKING DOWNSTREAM.

SCALE - VERT. 1:100
HORIZ. 1:2500

Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

REPRESENTATIVE CROSS-SECTIONS BIGHILL CREEK

DRAWN BY : M.G.M.
APPROVED BY : M Quazi
FIGURE NO. A-4
CHECKED BY : T. Waikold
DATE : June 17/86
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APPENDIX B
Hydrology Report

WATER RESOURCES MANAGEMENT SERVICES

TECHNICAL SERVICES DIVISION

HYDROLOGY BRANCH

FLOOD FREQUENCY ANALYSIS

COCHRANE FLOODPLAIN STUDY

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SYNOPSIS

This report presents details of flood frequency analyses of the Bow River, Jumpingpound Creek, and Bighill Creek in the vicinity of Cochrane. This study, in conjunction with the Calgary Floodplain Study, involves an examination of the annual flood series, an assessment of the stationarity of the annual flood series and the selection of a representative frequency distribution.

The 1:100 year return period flood estimates are 1590 cms for Bow River above Jumpingpound Creek, 1960 cms for Bow River at Calgary, 323 cms for Jumpingpound Creek at the Confluence of the Bow River, and 20.8 cms for Bighill Creek at the Confluence of the Bow River. For floodplain delineation purposes, coincidence of flood peaks should be assumed throughout the study area for the 1:100 year flood event.

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1. INTRODUCTION

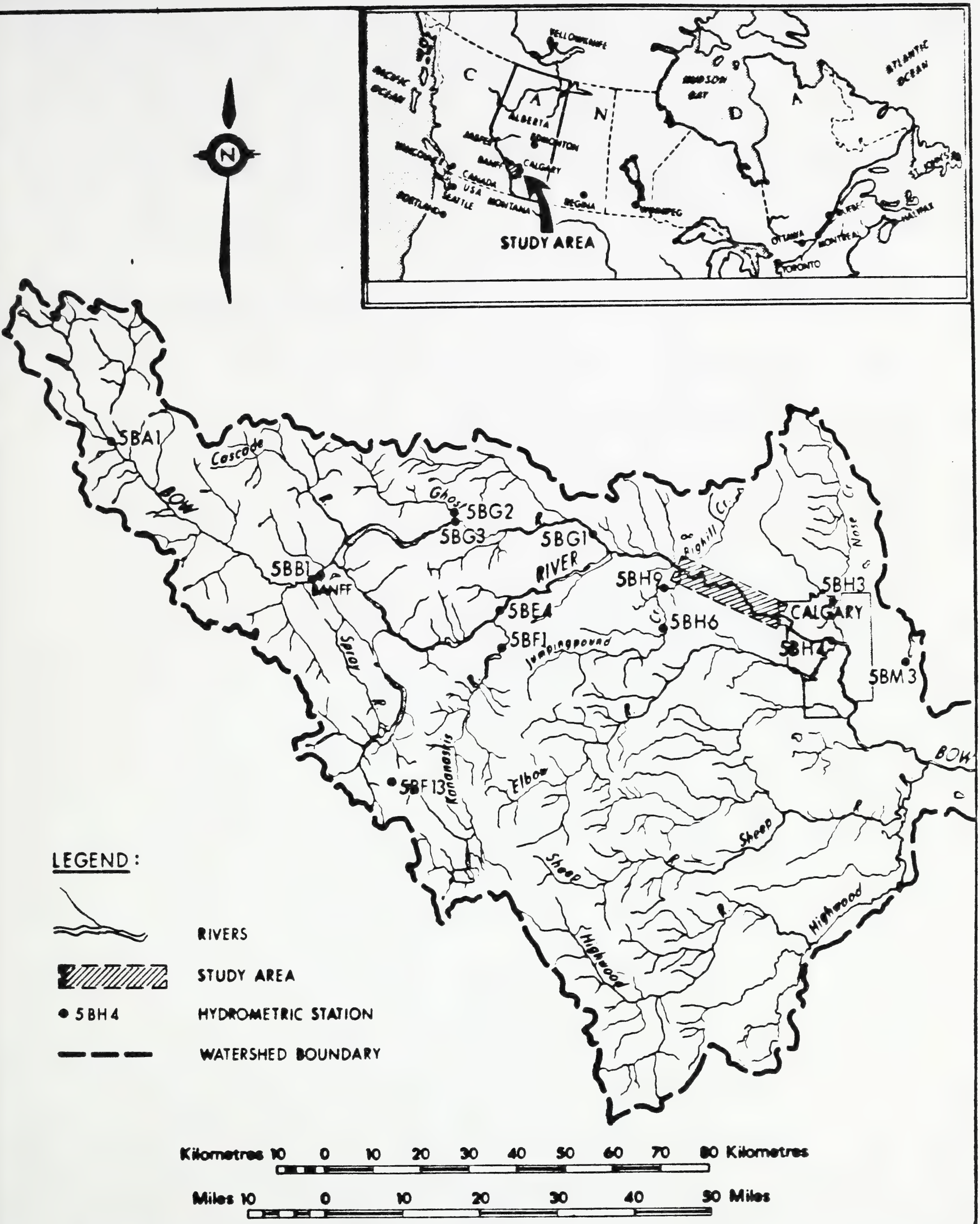
1.1 Study Area Elements

The Cochrane Floodplain Study area extends from the Bow River above the Confluence of Jumpingpound Creek to the Bow River at the City of Calgary. The regional setting of the study area is depicted in Figure 1.1. The Bow River above the Confluence of Jumpingpound Creek drains an area of 6,790 square kilometers and the Bow River at the City of Calgary drains an area of 7,870 square kilometers. The intermediate area comprises 606 square kilometers for the Jumpingpound Creek drainage basin, 173 square kilometers for the Bighill Creek drainage basin, and 308 square kilometers for the local drainage between the confluence of Bighill Creek and the City of Calgary.

Flood frequency estimates for the Bow River, Jumpingpound Creek and Bighill Creek are presented for the delineation of floodplain boundaries throughout the study area. This study determines the flood frequency estimates for the Cochrane Floodplain Study.

1.2 Related Studies

The downstream portion of the Bow River in the Cochrane Floodplain study extends to the upstream portion of the Bow River in the Calgary Floodplain Study[1] completed by Alberta Environment in 1983. Several topics pertinent to the present study were outlined in detail in the Calgary Floodplain Study. These include flood moderating influences on the Bow River, the selection of a flood frequency distribution, and an analysis of historic data for inclusion with the flood frequency distribution. Applicable information for this study is summarized from the Calgary Floodplain Study.



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	STUDY AREA ELEMENTS
SUBMITTED A. DE BOER, P. ENG. DATE	DESIGNED A. DE BOER, P. ENG. CHECKED	
APPROVED J. CARD, P. ENG. DATE	DRAWN V. DA SILVA CHECKED A. DE BOER, P. ENG.	SCALE AS SHOWN DATE
		FIGURE No. 1.1

Several reports have examined flooding potential through the City of Calgary. These reports are referenced in the Calgary Floodplain Study and provided valuable information for the flood frequency analyses of that study.

1.3 Scope of the Study

This study determines flood frequency estimates for the Bow River at Cochrane for use in delineating floodplain boundaries. The Bow River at the study location is analyzed using recorded flows on the Bow River between Lake Louise and Calgary. Flood frequency estimates for Jumpingpound Creek were determined from recorded data at two locations on this stream and flood frequency estimates for Bighill Creek were estimated by analogy with recorded flow data for Nose Creek at Calgary.

2. THE BOW RIVER

This section contains the analysis of the flood frequencies for the Bow River in the vicinity of Cochrane. Included in this section is the examination of the annual flood series, an assessment of flood moderating influences on flood peaks and the selection of a frequency distribution for the annual flood series.

A Bow River flood frequency analysis was determined from the flood record at station 05BA001 - Bow River at Lake Louise, station 05BB001 - Bow River at Banff, station 05BE004 - Bow River near Seebe, and station 05BH004 - Bow River at Calgary. The drainage area at each location is 422, 2,210, 5,150, and 7,870 square kilometers, respectively. The three latter stations were selected because each station had a substantial (40 or more years) period of record and each station recorded several of the major floods on the Bow River prior to 1933. The flood frequency estimates for Bow River at Lake Louise complete the Bow River flood frequency analysis. The 1932 flood, the largest flood on the Bow River for which records are readily available and the fourth largest recorded flood at Calgary in the historical period 1879 to 1982, was selected to verify the results of the flood frequency analysis.

2.1 Annual Flood Series

Two series of extremes are common to flood frequency analysis. The most widely used extreme value series is comprised of annual extremes. This series has a good theoretical basis for extrapolating the series beyond the range of observation. A criterion of the annual series is independence of events. The annual series of maximum

TABLE 2.1.1

ANNUAL FLOODS OF BOW RIVER AT LAKE LOUISE

Year	Daily Flow (cms)	Date	Peak Flow (cms)		Date
1911	58.3	Jun 24	60.5	e	Jun 24
1912	53.5	Aug 25	55.6	e	Aug 25
1913	54.9	Jun 11	57.1	e	Jun 11
1914	54.9	Jul 15	57.1	e	Jul 15
1915	84.7	Jun 26	87.5	e	Jun 26
1916	108.0	Jun 19	111.2	e	Jun 19
1917	45.3	Jul 17	47.2	e	Jul 17
1918	123.0	Jun 14	126.4	e	Jun 14
1919	47.9	Jun 22	49.9	e	Jun 22
1920	58.3	Jul 22	60.5	e	Jul 22
1964	25.9	Jul 9	27.2	e	Jul 9
1965	46.4	Jul 8	47.0		Jul 8
1966	39.6	Jun 1	40.2		Jun 1
1967	62.9	Jun 22	65.3	e	Jun 22
1968	50.1	Jul 12	51.0		Jul 12
1969	50.4	Jun 7	52.1		Jun 7
1970	37.7	Jun 5	39.1		Jun 7
1971	41.1	Jun 8	42.2		Jun 8
1973	43.3	Jun 24	45.6		Jun 24
1974	69.9	Jun 24	71.4		Jun 25
1975			44.5		Jul 14
1976	43.6	Jul 9	45.0		Sep 6
1977	41.9	Jun 9	43.7	e	Jun 9
1978	44.5	Jul 11	46.2		Jul 11
1979	37.1	Jul 22	38.4		Jul 21
1980	46.9	May 21	56.8		May 22
1981	55.7	May 26	56.5		May 26
1982	49.3	Jul 22	51.8		Jul 22

2.1.2 Bow River at Banff

Station 05BB001 - Bow River at Banff has recorded annual maximum daily discharges for the period 1909 to 1982. For years where the maximum instantaneous discharge was not identified, estimates were obtained from a least squares curve fit between maximum daily (Q_D) and maximum instantaneous (Q_I) discharge. Both parameters were available in 36 years. The relationship, in cfs units, is given in Equation 2.1.2.

$$Q_I = 1.0612\ Q_D^{0.99601} \qquad \text{(Equation 2.1.2)}$$

The index of determination (r^2) of Equation 2.1.2 is 0.993. This implies that 99.3 percent of the variation in the maximum instantaneous discharges is explained by the equation. The standard error of estimate for Equation 2.1.2 is about 2 percent. Table 2.1.2 lists the completed flood series for the Bow River at Banff.

2.1.3 Bow River near Seebe

Station 05BE004 - Bow River near Seebe has recorded annual maximum daily and maximum instantaneous discharges for the period 1923 to 1962 and 1979 to 1982. Table 2.1.3 lists the recorded flood series for the Bow River near Seebe.

2.1.4 Bow River at Calgary

The annual flood series for station 05BH004 - Bow River at Calgary (above Elbow River) was determined in the Calgary Floodplain Study. Table 2.1.4 summarizes the completed flood series.

The Bow River at Calgary (above Elbow River) has recorded annual maximum daily discharges for the period 1908 through 1982, except for 1951. The 1951 daily discharge was estimated to be 425 cms, as

TABLE 2.1.2

ANNUAL FLOODS OF BOW RIVER AT BANFF

Year	Daily Flow (cms)	Date	Peak Flow (cms)	Date
1909	314	Jul 7	326 e	Jul 7
1910	230	Jun 12	239 e	Jun 12
1911	264	Jun 14	274 e	Jun 14
1912	174	Aug 25	181 e	Aug 25
1913	232	Jun 11	241 e	Jun 11
1914	214	Jun 18	222 e	Jun 18
1915	236	Jun 27	245 e	Jun 27
1916	309	Jun 20	320 e	Jun 20
1917	174	Jun 17	181 e	Jun 17
1918	345	Jun 15	358 e	Jun 15
1919	185	Jun 22	192 e	Jun 22
1920	248	Jul 3	257 e	Jul 3
1921	171	Jun 9	178 e	Jun 9
1922	209	Jun 5	217 e	Jun 5
1923	377	Jun 14	399	Jun 14
1924	167	Jul 5	174	Jul 5
1925	212	May 23	220 e	May 23
1926	130	Jul 7	135 e	Jul 7
1927	221	Jun 27	228	Jun 27
1928	289	May 28	300 e	May 28
1929	215	Jun 2	233	Jun 2
1930	263	Jun 8	277	Jun 8
1931	187	Jun 18	194 e	Jun 18
1932	279	Jun 3	283	Jun 3
1933	311	Jun 17	328	Jun 17
1934	269	May 31	279 e	May 31
1935	197	Jun 16	205 e	Jun 16
1936	219	Jun 1	227 e	Jun 1
1937	148	Jun 17	154 e	Jun 17
1938	220	Jun 23	228 e	Jun 23
1939	178	May 29	185 e	May 29
1940	204	May 26	212 e	May 26
1941	126	Jun 25	131 e	Jun 25
1942	166	Jul 5	173 e	Jul 5
1943	209	Jul 10	217 e	Jul 10
1944	158	Jun 12	164 e	Jun 12
1945	126	Jun 22	131 e	Jun 22
1946	204	May 29	221	May 29
1947	167	Jun 11	174 e	Jun 11
1948	292	Jun 9	303 e	Jun 9
1949	121	Jun 7	126 e	Jun 7
1950	286	Jun 21	297 e	Jun 21
1951	243	Jun 16	252 e	Jun 16
1952	155	Jun 30	161 e	Jun 30
1953	260	Jun 14	281	Jun 13
1954	286	Jul 8	289	Jul 8
1955	246	Jun 24	251	Jun 14
1956	257	Jun 5	274	Jun 5
1957	152	May 20	157	May 20
1958	191	May 26	198	May 26
1959	212	Jun 22	216	Jun 22
1960	182	Jul 1	187	Jul 1
1961	266	Jun 7	271	Jun 6
1962	184	Jun 26	195	Jun 26
1963	183	Jun 19	186	Jul 9
1964	246	Jun 14	255 e	Jun 14
1965	289	Jun 19	297	Jun 19
1966	225	Jun 1	235	Jun 1
1967	275	Jun 22	285 e	Jun 22
1968	191	Jun 27	197	Jun 27
1969	203	Jun 6	209	Jun 6
1970	155	Jun 5	163	Jun 5
1971	199	Jun 7	203	Jun 7
1972	311	Jun 12	320	Jun 12
1973	215	Jun 24	222	Jun 24
1974	317	Jun 25	320	Jun 25
1975	144	Jul 14	149	Jul 14
1976	191	Jul 1	197	Jul 1
1977	207	Jun 9	221	Jun 9
1978	189	Jun 6	197	Jun 7
1979	150	Jun 13	157	Jun 13
1980	190	May 22	197	May 22
1981	227	May 27	233	May 27
1982	192	Jun 22	197	Jun 23

TABLE 2.1.3
ANNUAL FLOODS OF BOW RIVER NEAR SEEBE

Year	Daily Flow (cms)	Date	Peak Flow (cms)	Date
1923	663	Jun 15	697	Jun 15
1924	334	Jul 5	337	Jul 5
1925	343	Jun 23	362	Jun 23
1926	212	Jul 8	274	Jul 10
1927	411	Jun 11	583	Jun 27
1928	493	Jun 29	515	Jun 29
1929	555	Jun 3	699	Jun 3
1930	374	Jun 9	453	Jun 9
1931	265	Jun 19	275	Jun 19
1932	762	Jun 3	903	Jun 2
1933	583	Jun 18	705	Jun 17
1934	416	May 31	430	May 31
1935	289	Jun 17	309	Jun 1
1936	334	Jun 2	343	May 30
1937	232	Jun 18	306	Jun 19
1938	419	Jun 23	453	Jun 22
1939	306	Jul 2	328	Jul 3
1940	280	May 26	306	May 27
1941	173	Jun 15	279	Jun 19
1942	289	Jun 9	459	Jun 9
1943	320	Jul 10	368	Jul 27
1944	215	Jun 13	340	Jul 7
1945	274	Jun 22	419	May 31
1946	323	May 29	402	May 28
1947	306	Jun 12	413	Jun 3
1948	419	May 24	498	May 25
1949	193	Jun 8	248	May 16
1950	343	Jun 22	348	Jun 22
1951	331	Jul 7	385	Jul 7
1952	249	Jul 6	283	Jul 6
1953	354	Jun 14	368	Jun 13
1954	323	Jul 9	334	Jun 16
1955	281	Jun 24	368	Jun 24
1956	297	Jun 6	411	Jun 4
1957	203	May 21	220	Jun 5
1958	215	Jun 11	340	Jun 11
1959	249	Jun 24	317	Jun 23
1960	217	Jul 2	258	Jul 1
1961	368	Jun 6	411	Jun 6
1962	250	Jun 27	276	Jun 27
1979	166	May 28	220	May 28
1980	265	Jun 19	326	Jun 19
1981	343	May 27	379	May 28
1982	257	Jun 23	312	Jun 23

TABLE 2.1.4
ANNUAL FLOODS OF BOW RIVER AT CALGARY ABOVE ELBOW RIVER
(Completed Series)

Year	Daily Flow (cms)	Date	Peak Flow (cms)	Date
1879			2270	
1897			2270	June 18
1902			1560	July 04
1908	379	June 06	422 e	June 06
1909	558	July 07	626 e	July 07
1910	379	June 13	422 e	June 13
1911	467	June 25	521 e	June 25
1912	430	July 10	479 e	July 10
1913	416	June 12	463 e	June 12
1914	405	June 18	451 e	June 18
1915	796	June 26	1130	June 26
1916	767	June 21	810	June 21
1917	436	June 03	486 e	June 03
1918	532	June 16	595 e	June 16
1919	411	Aug. 05	459	Aug. 05
1920	510	July 13	515	July 13
1921	337	June 09	374 e	June 09
1922	365	June 06	377	June 06
1923	714	June 14	841	July 03
1924	377	July 05	385	July 05
1925	385	June 23	394	June 23
1926	259	Sept 11	277	Sept 11
1927	547	June 11	564	June 11
1928	558	July 01	575	July 01
1929	1150	June 03	1320	June 03
1930	399	June 10	428	June 09
1931	306	June 20	328	June 20
1932	1160	June 03	1520	June 03
1933	612	June 18	686 e	June 18
1934	447	June 01	513	June 01
1935	374	June 17	394	June 19
1936	408	June 03	428	June 02
1937	257	June 18	297	June 23
1938	413	June 23	459	June 23
1939	309	July 02	320	July 03
1940	271	May 25	323	May 25
1941	178	June 16	197	June 16
1942	303	June 09	365	June 09
1943	323	July 05	365	July 16
1944	214	June 14	251	June 13
1945	306	June 23	377	May 31
1946	354	May 30	402	May 29
1947	374	June 10	425	June 12
1948	558	May 25	595	May 24
1949	200	June 09	228	June 08
1950	419	June 23	490	June 23
1951	425 e	July 07	473 e	July 07
1952	408	July 24	487	July 07
1953	513	June 14	578	June 23
1954	388	Aug. 26	428	July 06
1955	365	June 25	416	June 24
1956	306	June 07	377	June 05
1957	270	June 09	320	June 09
1958	250	June 13	281	May 29
1959	306	June 28	326	June 27
1960	289	July 02	306	July 02
1961	391	June 07	396	June 07
1962	249	June 28	264	June 29
1963	317	June 30	450	June 30
1964	351	June 16	377	June 19
1965	456	June 20	473	June 19
1966	345	June 04	354	June 04
1967	382	June 24	428	May 31
1968	256	June 13	265	June 29
1969	399	June 30	481	June 29
1970	331	June 17	334	June 17
1971	362	June 07	388	June 09
1972	402	July 03	425	July 03
1973	334	June 26	354	June 26
1974	476	June 26	484	June 26
1975	224	July 16	242	July 10
1976	249	Aug. 07	253	Aug. 07
1977	208	June 10	229 e	June 10
1978	238	June 12	292	July 19
1979	141	May 30	160	May 30
1980	302	June 19	370	June 19
1981	425	May 28	427	May 29
1982	276	June 24	305	June 30

determined from flow data recorded on Bow River below Ghost Dam and from a previous Bow River flood frequency analysis by Alberta Environment. Recorded maximum annual flows for Bow River below Ghost Dam in 1951 were 396 cms for the daily discharge and 450 cms for the instantaneous discharge. The 1951 flood for Bow River at Calgary was estimated to be 425 cms for the daily discharge and 473 cms for the instantaneous discharge.

Estimates of annual maximum instantaneous discharge, for those years where this parameter was not recorded, were determined from a least squares curve fit between daily (Q_D) and instantaneous (Q_I) discharge for the 62 years that recorded both parameters. This relationship, in metric units, is given in Equation 2.1.4. The index of determination (r^2) indicates that 96.33 percent of the variation between the daily discharge and the instantaneous discharge is explained by the equation.

$$Q_I = 1.0072\ Q_D^{1.0166} \qquad \text{(Equation. 2.1.4)}$$

Table 2.1.4 also provides historical flood estimates for the Bow River at Calgary for the years 1879, 1897, and 1902. A historical flood is defined as a flood of greater magnitude than the largest flood recorded in the systematic period of stream gauging records. The historical flood estimates are included in the flood frequency analysis at this location.

2.1.5 Stationarity of the Annual Flood Series

The Bow River basin has undergone considerable change since the start of systematic streamflow records at Calgary in 1908. Land use changes, water diversions and river regulation are considered the

primary causes of possible changes to peak flows on the Bow River system. Therefore, the stationarity of the annual flood series is examined in this section to determine whether the difference between the means and the variances of the early record and the later record of the systematic data are statistically significant. The data for Bow River at Banff and Bow River at Calgary was chosen because both stations share a similar period of record and each sub-sample size will reliably define both the variance and the mean of the sub-sample.

2.1.5.1 Bow River at Banff

The systematic flood series record is divided into two periods; 1909 to 1945 and 1946 to 1982. The mean and standard deviation for the early period are 230 cms and 63.7 cms, respectively. Similarly, these parameters for the later period are 224 cms and 51.9 cms. These two samples are tested to determined if they belong to the same population.

The first test to be applied is the variance ratio test, known as the F test. The null hypotheses for this test is that the variances of the two samples belong to the same population. As the computed F of 1.51 is less than the tabulated value at the 5 percent significance level of 1.76, the null hypothesis is accepted.

The second test to be applied is the t test. The null hypothesis of this test is that the two samples are from the same population. The t test assesses the probability of the difference between the sample means occurring. Since the computed t of 0.44 is less than the tabulated t at the 5 percent significance level of 2.00, the null hypothesis is accepted.

Both the F test the t test indicate the two samples from the annual flood series belong to the same population. It is concluded that the systematic record of flood peaks of the Bow River at Banff is stationary.

2.1.5.2 Bow River at Calgary

The systematic flood series record is divided into two periods; 1908 to 1945 and 1946 to 1982. The mean and standard deviation for the early period are 519 cms and 278 cms, respectively. Similarly, these parameters for the later period are 372 cms and 100 cms. The two samples are tested with the F test and the t test to determine if they belong to the same population.

The computed F of 7.73 is greater than the tabulated value of 1.76 at the 5 percent significance level and is also greater than the tabulated value of 2.23 at the 1 percent significance level. Therefore, the null hypothesis is not accepted and indicates that the two samples may not belong to the same population. The t test was not examined since the null hypothesis of this test assumes that the two samples belong to the same population and the two variance estimates must be consistent with this hypothesis.

2.1.5.3 Conclusions

The statistical significance tests indicated that the systematic record of flood peaks of the Bow River at Banff is stationary and that the flood record of the Bow River at Calgary may be non-stationary. Section 2.2 examines possible flood moderating influences on the system to determine if a change in the flow pattern can be

identified. Flood frequency estimates should be determined from the date of any identified change to the present since this period represents the existing flow pattern for the Bow River system.

2.2 Flood Moderating Influences

Flood moderating influences on the Bow River system above the City of Calgary were examined in detail in the Calgary Floodplain Study. Land use changes, water diversions, and storage reservoir influences were examined for their influence on the annual flood peak and are summarized in this section.

2.2.1 Land Use Changes

The only significant land use change in proportion to the total drainage basin is the effect of forest cover on runoff. Forest cover will intercept initial precipitation until the cover is saturated and will also decrease the intensity of the rainfall reaching the ground. Interception will also increase evapotranspiration losses and thus effectively reduce both snowmelt and rainfall runoff. Thus, it may be assumed that the existence of forest cover will decrease the peak runoff rate, and conversely, that a lack of forest cover will increase the peak runoff rate.

Forest cover may, however, be depleted or replenished at any time by man or nature and should not be considered as a permanent change on the flood pattern. Thus, in a hydrologic flood frequency analysis, the early record and later record should be combined regardless of forest cover influences.

2.2.2 Water Diversions

Consumptive water diversions on the Bow River system above the City of Calgary are limited to minor licenced water supply systems for municipal, industrial, and domestic uses. The quantity of these diversions during the short duration of a flood wave travelling through the system will insignificantly influence the peak flow rate of the flood because a small constant flow rate is applicable to these diversion systems.

The Bow River system above the City of Calgary also has two non-consumptive diversion schemes. These are the Smith-Dorrien Creek diversion and the Ghost River diversion. The Smith-Dorrien Creek diversion diverts water from a 36 square kilometer area, which naturally drains into the Kananaskis Lakes, into the Spray Reservoir system through the Mud Lake diversion canal. Recorded flows, at station 05BF013 - Mud Lake Diversion Canal, from this diversion are less than 0.6 percent of recorded peak flows at Calgary and would not influence a hydrologic flood frequency analysis. Storage reservoir influences will apply to water quantities diverted by the Smith-Dorrien Creek diversion.

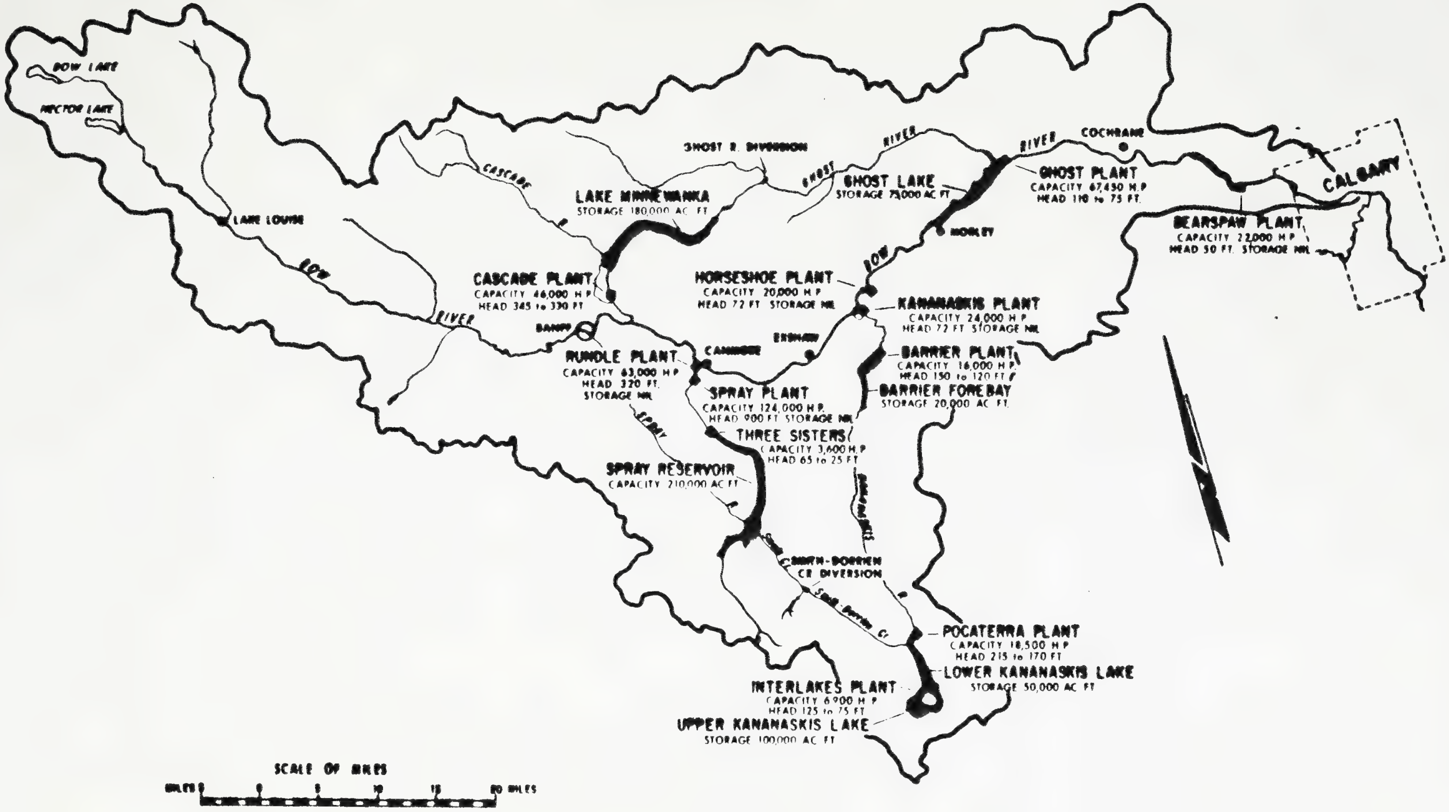
The Ghost River diversion scheme diverts water from a 220 square kilometer area, in the headwaters of the Ghost River, into Lake Minnewanka. A comparison of recorded flows at station 05BG003 - Ghost River Diversion to Lake Minnewanka and at station 05BG002 - Ghost River near Black Rock Mountain (immediately upstream of the diversion) shows that about 65 percent of the water from the 220 square kilometer area is diverted into the Lake Minnewanka system. Storage reservoir influences will apply to water quantities influenced by the Ghost River diversion.

The Ghost River diversion dam diverts all of the Ghost River flow up to 7.1 cms into the diversion canal leading to Lake Minnewanka. When the Ghost River flow exceeds 34.0 cms, the diverted flow rate approaches 11.3 cms. A reduction of 11.3 cms for a major flood on the Ghost River represents less than 3 percent of the Ghost River flow. For example, the largest recorded peak flow (at station 05BG001 - Ghost River near Cochrane) on June 2, 1932 would be reduced to 382 cms from the recorded 394 cms. Negligible flood moderating influences are assumed for major floods on the Ghost River due to the diversion into Lake Minnewanka.

2.2.3 Storage Reservoir Influences

A detailed account of the history of storage reservoirs on the Bow River above Calgary is provided in the 1973 City of Calgary Flood Study[3]. Figure 2.2.3 shows these existing power developments and Tables 2.2.3(a) and 2.2.3(b) show the increase in live storage and the tributary drainage areas of the various reservoirs as they were built on the Bow River. Conclusions for the Cochrane Floodplain Study may be inferred from the conclusions for the Bow River at Calgary.

The Ghost reservoir is the only reservoir located low enough in the Bow River drainage basin to control a significant portion (78 percent) of the area contributing to floods in Calgary. The Ghost reservoir only accounts for 12 percent of the total live storage on the Bow River. The remaining 88 percent of the live storage controls only 27 percent of the Bow River basin. Barrier reservoir accounts for only 3 percent of the total live storage. Thus, 85 percent of the total live storage in the Bow River basin controls 20 percent of the drainage area of the Bow River above Elbow River.



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	EXISTING POWER DEVELOPMENTS BOW RIVER DRAINAGE BASIN	
SUBMITTED A. DE BOER, P. ENG. DATE JUNE, 1981	DESIGNED A DE BOER, P. ENG CHECKED		
APPROVED J. CARD, P. ENG. DATE JUNE, 1981	DRAWN V. DA SILVA CHECKED A. DE BOER, P. ENG.	SCALE AS SHOWN DATE JUNE, 1981	**FIGURE No.** 2.2.3

TABLE 2.2.3 (a)

INCREASE OF LIVE STORAGE IN THE BOW VALLEY 1912-1955

Year	Reservoir	Reservoir Live Storage (dam^3)	Cumulative Live Storage in Bow Valley (dam^3)
1912	Minnewanka (First Stage)	54,000	54,000
1930	Ghost	93,000	147,000
1932	Upper Kananaskis (First Stage)	44,000	191,000
1942	Minnewanka (Second Stage)	220,000*	357,000
1942	Upper Kananaskis (Second Stage)	122,000*	435,000
1947	Barrier	24,000	459,000
1951	Spray	257,000	716,000
1955	Lower Kananaskis	61,000	777,000

* Includes first stage live storage

TABLE 2.2.3 (b)

TRIBUTARY DRAINAGE AREAS OF RESERVOIRS IN BOW VALLEY

River	Reservoir	Fully Supply Level (m)	Tributary Drainage Area (sq.km.)	(%)*
Spray	Spray	1702	554	7.0
Kananaskis	Upper Kananaskis	1702	228	2.9
Kananaskis	Lower Kananaskis	1667	355	4.5**
Cascade	Minnewanka	1475	653	8.3***
Kananaskis	Barrier	1376	951	12.1†
Bow	Ghost	1190	6140	78.0††

* Tributary Area as percentage of the total drainage area of Bow River at Langevin Bridge (7,870 square kilometers)

** Includes area tributary to Upper Kananaskis Lake

*** Excludes area tributary to Ghost River diversion (220 square kilometers)

† Includes area tributary to Upper and Lower Kananaskis Lakes

†† Includes area tributary to reservoirs

The reservoirs on the Bow River system are filled through the spring and summer to ensure that sufficient water is stored to support power generation throughout the following winter. Thus, these reservoirs cannot be relied upon to have all of the live storage available for reducing the peak flow during a major flooding event. The large summer storms, which produce the severest floods at Calgary, deposit the majority of their precipitation east of the front range of the Rocky Mountains and downstream of the storage reservoirs which contain 85 percent of the live storage in the basin. No significant flood control can be expected from these reservoirs.

The Ghost Reservoir is suitably situated for potential control of floods on the Bow River. The influence of this reservoir in moderating flood peaks is examined in the Calgary Floodplain Study[1]. In the study, natural flood hydrographs for six years are recreated by adding storage changes in the Ghost reservoir to the recorded flows below the dam. The results of this analysis, shown in Table 2.2.3(c), indicate that the Ghost reservoir has a minor influence in moderating flood peaks. In three of the six years analyzed, the maximum reservoir release exceeds the natural daily maximum.

For purposes of this study, the effect of reservoirs in the Bow River basin on flood peak reduction is assumed negligible and the recorded flood series is assumed to approximate the natural flood series for downstream reaches of the Bow River.

TABLE 2.2.3 (c)

GHOST RESERVOIR INFLUENCES ON FLOOD PEAKS
FOR BOW RIVER BELOW GHOST DAM

Year	Estimated Daily Natural Flow (cms)	Recorded Daily Regulated Flow (cms)
1933	578	575
1938	399	415
1957	217	244
1973	326	314
1974	504	504
1976	240	244

2.2.4 Conclusions on Flood Moderating Influences

The non-stationarity of the Bow River at Calgary flood data necessitated the investigation of possible changes in the river system flow pattern. An evaluation of possible flood moderating influences led to the following conclusions for the Bow River system:

1. the effect of forest cover should not be relied upon in the evaluation of possible future floods on the Bow River at Cochrane and at Calgary because the forest cover may be depleted or replenished at any time by man or nature,
2. negligible flood moderating influences from diversions should be assumed for extreme floods on the Bow River system,
3. the influence of storage reservoirs in moderating flood peaks on the Bow River at Cochrane and at Calgary is negligible because (1) 85 percent of the available live storage can only influence

20 percent of the drainage basin above Calgary, (2) the availability of live storage in the reservoirs cannot be relied upon for reduction of peak flows since present reservoir operation for power conflicts with flood control demands, (3) the large summer storms, which produce the severest floods, deposit the majority of their precipitation downstream of the storage reservoirs which contain 85 percent of the live storage in the basin, (4) it is shown that the Ghost Reservoir has negligible influence in reducing peak flood flows on the Bow River,

4. no significant flood moderating influences on the system could be identified; therefore, the recorded flood series is used to determine the frequency of major floods on the Bow River above Calgary.

2.3 Selection of a Flood Frequency Distribution

Maximum annual instantaneous discharges are a series of random events for which the population distribution is unknown. However, to facilitate assigning flood probabilities, it is necessary to associate a frequency distribution with these events. Several statistical distributions are applied to the Bow River data to identify an appropriate distribution.

2.3.1 Selection Criterion

The criterion that is used to select a statistical distribution is based on the expected probability of a given event being equalled or exceeded in the series of recorded events. The probability theory can be represented by Equation 2.3.1.

$$P_{nr} = p^n q^{r-n} \left(\frac{r!}{(r-n)!n!}\right) \qquad \text{........... (Equation 2.3.1)}$$

where P_{nr} = the probability of a particular event being equalled or exceeded n times in a sample of r events

p = 1/t where t is the return period of the event

q = 1 - p

The selection criterion is limited to the systematic period of record. The assumption is made that a distribution representative for the systematic record will also be representative for a historically adjusted period of record. This will apply to the historical floods documented for the Bow River at Calgary. The probability of various return period events occurring for the record lengths of Bow River at Lake Louise, at Banff, near Seebe, and at Calgary are summarized in Table 2.3.1(a). All probabilities listed in the table are independent of distribution type and thereby provide a means of comparing one distribution to another.

Table 2.3.1(b) shows the number of events having a high percent chance of occurrence as a function of return period for the Bow River flood data. This forms the basis of the selection criterion. A particular distribution conforms to the criterion when its frequency curve indicates that the number of recorded events equalling or exceeding each return period flood estimate corresponds to the acceptable number of events listed in Table 2.3.1(b). A distribution meeting the selection criterion has a greater probability of being representative of the population than one not conforming to the criterion. Although it is possible that a distribution representative of the unknown population distribution may be rejected by the selection criterion, the decision is made to base distribution selection on the greater probability.

TABLE 2.3.1 (a)

PROBABILITY (%) OF THE EVENT OCCURRING n TIMES IN r YEARS

Number of Events (n)	Flood Event Return Period (years) 1:100	1:50	1:20	Remarks
		Bow River at Lake Louise n times in 28 years		
0	75.4	56.8	23.8	82% - 96%
1	21.3	32.5	35.0	Chance of
2	2.9	8.9	24.9	Occurrence
3	0.3	1.6	11.4	
4	0.0	0.2	3.7	
5	0.0	0.0	0.9	
6	0.0	0.0	0.2	
		Bow River at Banff n times in 74 years		
0	47.5	22.4	2.2	
1	35.5	33.9	8.8	
2	13.1	25.2	16.8	72% - 83%
3	3.2	12.4	21.2	Chance of
4	0.6	4.5	19.8	Occurrence
5	0.1	1.3	14.6	
6	0.0	0.3	8.8	
		Bow River near Seebe n times in 44 years		
0	64.3	41.1	10.5	78% - 93%
1	28.6	36.9	24.2	Chance of
2	6.2	16.2	27.4	Occurrence
3	0.9	4.6	20.2	
4	0.1	1.0	10.9	
5	0.0	0.2	4.6	
6	0.0	0.0	1.6	
		Bow River at Calgary n times is 75 years		
0	47.1	22.0	2.1	
1	35.7	33.6	8.4	
2	13.3	25.4	16.4	72% - 83%
3	3.3	12.6	21.0	Chance of
4	0.6	4.6	19.9	Occurrence
5	0.1	1.3	14.9	
6	0.0	0.3	9.1	

TABLE 2.3.1 (b)

NUMBER OF EVENTS HAVING A HIGH CHANCE OF OCCURRENCE

Return Period (Years)	Number of Events (n)	Chance of Occurrence (%)
	Bow River at Lake Louise	
100	0 or 1	96.7
50	0 or 1	89.3
20	0, 1 or 2	83.7
	Bow River at Banff	
100	0 or 1	83.0
50	0, 1 or 2	81.5
20	2, 3, 4, or 5	72.4
	Bow River near Seebe	
100	0 or 1	92.9
50	0 or 1	78.0
20	0, 1, 2, 3, or 4	93.2
	Bow River at Calgary	
100	0 or 1	82.8
50	0, 1 or 2	81.0
20	2, 3, 4, or 5	72.2

2.3.2 Distribution Selection

Flood frequency estimates for the Bow River at Lake Louise, at Banff, near Seebe, and at Calgary are determined from seven commonly used statistical distributions. The distributions are Gumbel I, log-Gumbel I, normal, log-normal, 3-parameter log normal, Pearson III and log-Pearson III. Details on these distributions are found in several publications (Chow, 1964; Grey, 1970; Kite, 1976) and are not presented in this report. The majority of the distribution parameters are computed using the maximum likelihood theory. The exception is the Pearson III distribution, where sample skewness exceeds the maximum of 2 required for a maximum likelihood solution. In this case, the method of moments is used to determine distribution parameters. The log-Pearson III analysis is presented for both methods.

Table 2.3.2(a) lists flood frequency estimates of the distributions for the 1:100, 1:50, and 1:20 year return period events. The range of the estimates for the various distributions for a common data set clearly indicates the need for a selection criterion. The distributions are applied to the selection criterion, the results of which are listed in Table 2.3.2(b).

The Pearson III distribution based on method of moments is the only distribution accepted by the selection criterion for all of the data sets. The Pearson III distribution offers considerable flexibility in that the skewness of the distribution, within the theoretical limits of skewness (C_s) given in Equation 2.4, is determined from the data sample. This distribution also has a lower boundary which ensures

TABLE 2.3.2 (a)

BOW RIVER FLOOD FREQUENCY ESTIMATES (cms)

Distribution	Return Period (Years) 1:100	1:50	1:20
		Bow River at Lake Louise	
Gumbel I	108	99	87
log-Gumbel I	143	120	96
normal	102	97	88
log-normal	111	102	90
log-normal-3	120	108	92
Pearson III[1]	127	114	98
log-Pearson III	120	107	91
log-Pearson III[1]	137	118	96
		Bow River at Banff	
Gumbel I	423	389	344
log-Gumbel I	488	425	354
normal	362	346	322
log-normal	397	371	334
log-normal-3	396	370	334
Pearson III[1]	382	361	330
log-Pearson III	390	366	331
log-Pearson III[1]	394	368	333
		Bow River near Seebe	
Gumbel I	748	685	602
log-Gumbel I	1024	860	681
normal	720	681	623
log-normal	765	703	620
log-normal-3	887	784	656
Pearson III[1]	868	783	668
log-Pearson III	894	783	650
log-Pearson III[1]	924	803	660
		Bow River at Calgary	
Gumbel I	955	866	747
log-Gumbel I	1381	1120	847
normal	966	905	814
log-normal	1010	910	778
log-normal-3	1090	960	801
Pearson III[1]	1326	1136	892
log-Pearson III	1110	968	798
log-Pearson III[1]	1266	1068	838

1 based on method of moments

TABLE 2.3.2 (b)

SELECTION CRITERION COMPARISONS

Distribution	Return Period (Years) 1:100	1:50	1:20	Remarks
Bow River at Lake Louise				
Gumbel I	2	2	3	Reject
log-Gumbel I	0	1	2	Accept
normal	2	2	3	Reject
log-normal	2	2	2	Reject
log-normal-3	1	2	2	Reject
Pearson III[1]	0	1	2	Accept
log-Pearson III	1	2	2	Reject
log-Pearson III[1]	0	1	2	Accept
Bow River at Banff				
Gumbel I	0	1	2	Accept
log-Gumbel I	0	0	2	Accept
normal	1	2	4	Accept
log-normal	1	1	2	Accept
log-normal-3	1	1	2	Accept
Pearson III[1]	1	1	2	Accept
log-Pearson III	1	1	2	Accept
log-Pearson III[1]	1	1	2	Accept
Bow River near Seebe				
Gumbel I	1	4	4	Reject
log-Gumbel I	0	1	4	Accept
normal	1	4	4	Reject
log-normal	1	2	4	Reject
log-normal-3	1	1	4	Accept
Pearson III[1]	1	1	4	Accept
log-Pearson III	1	1	4	Accept
log-Pearson III[1]	0	1	4	Accept
Bow River at Calgary				
Gumbel I	3	3	5	Reject
log-Gumbel I	1	3	3	Reject
normal	3	3	4	Reject
log-normal	3	3	5	Reject
log-normal-3	3	3	5	Reject
Pearson III[1]	1	2	3	Accept
log-Pearson III	3	3	5	Reject
log-Pearson III[1]	2	3	4	Reject

---

[1] based on method of moments

that negative floods for lower return periods are not computed for positively skewed data sets common for almost all hydrologic events. The decision is, therefore, to use the Pearson III distribution in assigning flood probabilities for the Bow River flood data.

2.4 Flood Frequency Estimates

Flood frequency estimates for the Bow River at Lake Louise, at Banff, near Seebe and at Calgary are determined to estimate Bow River flood frequencies at the Cochrane Study area. The Pearson III frequency distribution, where the distribution parameters are computed using the method of moments, is used to assign flood probabilities. As the sample size is small, the analysis incorporates the theoretical limits of skewness (C_s) shown in Equation 2.4. The coefficient of variation (C_v) is equal to the standard deviation divided by the mean of the data sample and Kmin is equal to the minimum recorded discharge divided by the mean discharge of the data sample.

$$2C_v < C_s < 2C_v/(1-\text{Kmin}) \qquad \ldots\ldots\ldots\ldots\ldots \text{(Equation 2.4)}$$

2.4.1 Bow River at Banff

Table 2.4.1 lists flood frequency estimates for the Bow River at Banff for three different periods of record. Estimates based on the years 1911 to 1920, 1964 to 1971, and 1973 to 1982 (which represents the years of available data for Bow River at Lake Louise) are presented to determine whether this period is similar to the estimates for the 1909 to 1982 data. Estimates based on the years 1923 to 1962 and 1979 to

TABLE 2.4.1

FLOOD FREQUENCY ESTIMATES
BOW RIVER AT BANFF

Return Period (Years)	Annual Maximum Instantaneous Discharge (cms)		
	(1911-1920, 1964-1971, 1973-1982)	(1923-1962, 1979-1982)	(1909-1982)
100	379	385	382
50	356	361	361
20	324	328	330
10	298	300	304
5	269	268	274
2	222	215	222

TABLE 2.4.2

FLOOD FREQUENCY ESTIMATES
BOW RIVER AT LAKE LOUISE

Return Period (Years)	Annual Maximum Instantaneous Discharge (cms)
100	127
50	114
20	98
10	86
5	71
2	51

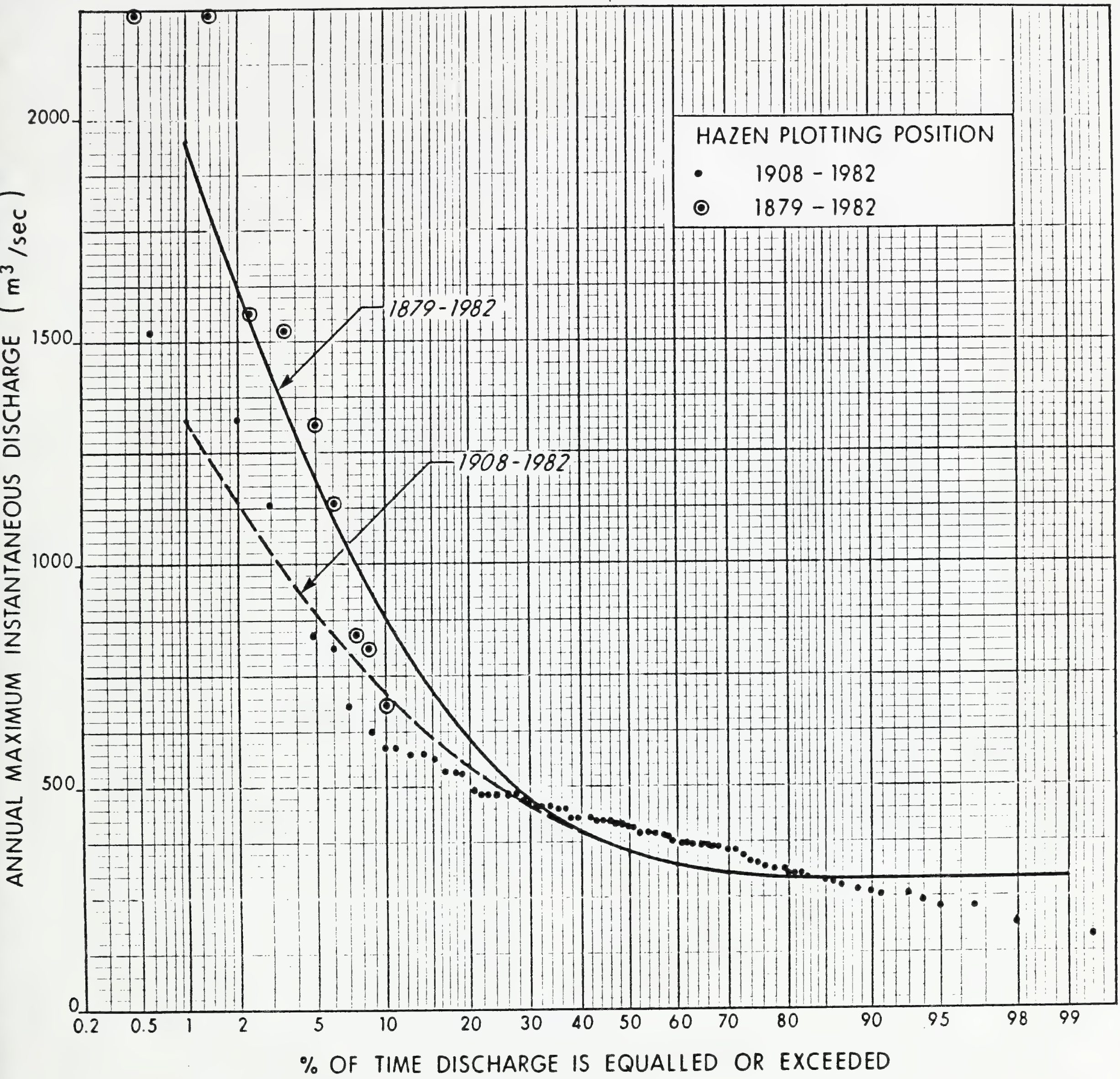
1982 (which represents the years of available data for the Bow River near Seebe) are presented to determine whether this period is similar to the estimates for the 1909 to 1982 data. Table 2.4.1 shows that the flood frequency estimates are similar for the 3 different periods of record and indicates stationarity in the flood record at this location. Thus, the 1909 to 1982 data for Bow River at Banff provides realistic flood frequency estimates at this location.

2.4.2 Bow River at Lake Louise

Table 2.4.2 lists the flood frequency estimates for the Bow River at Lake Louise based on the years 1911 to 1920, 1964 to 1971, and 1973 to 1982. Section 2.4.1 shows that flood frequency estimates for Bow River at Banff, for this period, are similar to the estimates for the 74 year period 1909 to 1982. The flood frequency estimates for Bow River at Lake Louise (based on the 28 years of recorded data) are representative for this location since the Bow River at Lake Louise is expected to exhibit the stationarity indicated by the data for Bow River at Banff.

2.4.3 Bow River at Calgary

The Pearson III frequency analysis of the Bow River at Calgary is based on the flood series listed in Table 2.1.4. The historical period 1879 to 1982 is incorporated into the analysis, using techniques outlined in Appendix A, with the 1879, 1897, and 1902 floods established as the three largest floods having occurred in the period. Figure 2.4.3 shows the flood frequency curve for the Bow River at Calgary. The



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	FLOOD FREQUENCY CURVE BOW RIVER ABOVE ELBOW RIVER PEARSON TYPE III FREQUENCY DISTRIBUTION
SUBMITTED A DE BOER, P. ENG. DATE DEC., 1983	DESIGNED H. BIBERHOFER, E.I.T. CHECKED	
APPROVED M. MUSTAPHA, P. ENG. DATE DEC., 1983	DRAWN V. DA SILVA CHECKED H. BIBERHOFER, E.I.T.	SCALE AS SHOWN DATE DEC., 1983
		FIGURE No. 2.4.3

FILE NO.

figure illustrates the shift in the flood frequency curve between the systematic (1908 to 1982) period of record and the historical (1879 to 1982) period of record.

Table 2.4.4(a) lists flood frequency estimates for the Bow River at Calgary for two different periods of record. Estimates based on the years 1923 to 1962 and 1979 to 1982 (which represents the years of available data for Bow River near Seebe) are presented to determine whether this period is similar to the estimates for the 1879 to 1982 historical data. The table shows that the estimates for the two periods are not similar for the Bow River at Calgary and is discussed in Section 2.4.4. The historical period 1879 to 1982 utilizes all of the known data for the Bow River at Calgary and provides the best flood frequency estimates at this location.

2.4.4 Bow River near Seebe

Pearson Type III flood frequency estimates for the period 1923 to 1962 and 1979 to 1982 were determined for the Bow River at Banff, near Seebe and at Calgary to determine whether the 1923 to 1962 and 1979 to 1982 period for Bow River near Seebe was representative of the longer period represented by the data at Banff (1909 to 1982) and at Calgary (1879 to 1982). Table 2.4.4(a) lists the flood frequency estimates at the three locations on the Bow River.

Table 2.4.4 (a) shows that the flood frequency estimates for Bow River at Banff are similar for both the 1923 to 1962 and 1979 to 1982 data and the 1909 to 1982 data. The estimates for Bow River at Calgary for the 1923 to 1962 and 1979 to 1982 data are considerably different from the estimates for the 1879 to 1982 data. This was indicated by the stationarity of the flood record for Bow River at Banff

TABLE 2.4.4 (a)

BOW RIVER FLOOD FREQUENCY ESTIMATES
ANNUAL MAXIMUM INSTANTANEOUS DISCHARGE

	Annual Maximum Instantaneous Discharge (cms)		
Return Period (Years)	05BB001 Bow River at Banff	05BE004 Bow River near Seebe	05BH004 Bow River at Calgary
	Period of Record (1923 to 1962, 1979 to 1982)		
100	385	868	1330
50	361	783	1160
20	328	668	944
10	300	579	778
5	268	487	608
2	215	357	376
	(1909 to 1982)	Period of Record	(1879 to 1982)
100	382		1960
50	361		1620
20	330		1180
10	304		882
5	274		613
2	222		351

and the non-stationarity of the flood record for Bow River at Calgary. An examination of flood moderating influences concluded that the entire flood record should be used in the determination of future flood frequency estimates because no significant flood moderating influences could be identified. Therefore, the flood frequency estimates at both Banff and Calgary could equally influence the estimates near Seebe since the drainage area near Seebe (5150 square kilometers) is nearly half way between the drainage area at Banff (2210 square kilometers) and at Calgary (7870 square kilometers).

Table 2.4.4 (b) gives flood frequency estimates for the Bow River near Seebe. The minimum estimates were determined by multiplying the 1923 to 1962 and 1979 to 1982 estimates near Seebe by the ratio of the long term (1909 to 1982) divided by the short term (1923 to 1962 and 1979 to 1982) estimates for Bow River at Banff and implies that the flood record at Seebe exhibits the stationarity shown by the flood record at Banff. The maximum estimates were determined by multiplying the 1923 to 1962 and 1979 to 1982 estimates near Seebe by the ratio of the long term (1879 to 1982) divided by the short term (1923 to 1962 and 1979 to 1982) estimates for Bow River at Calgary and implies that the flood record at Seebe exhibits the variability shown by the flood record at Calgary. The average of the maximum and minimum estimates are also provided and Sections 2.5 and 2.6 will show that the average estimates are representative for the Bow River near Seebe.

2.5 Flood Frequency Analysis

Bow River flood frequency estimates at Lake Louise, at Banff, near Seebe, and at Calgary were determined in Section 2.4. These estimates provide the basis for estimating flood frequencies for the Bow

TABLE 2.4.4 (b)

FLOOD FREQUENCY ESTIMATES
BOW RIVER NEAR SEEBE

	Annual Maximum Instantaneous Discharge (cms)		
Return Period (Years)	Minimum	Average	Maximum
100	861	1070	1280
50	783	937	1090
20	672	754	835
10	587	622	656
5	498	495	491
2	369	351	333

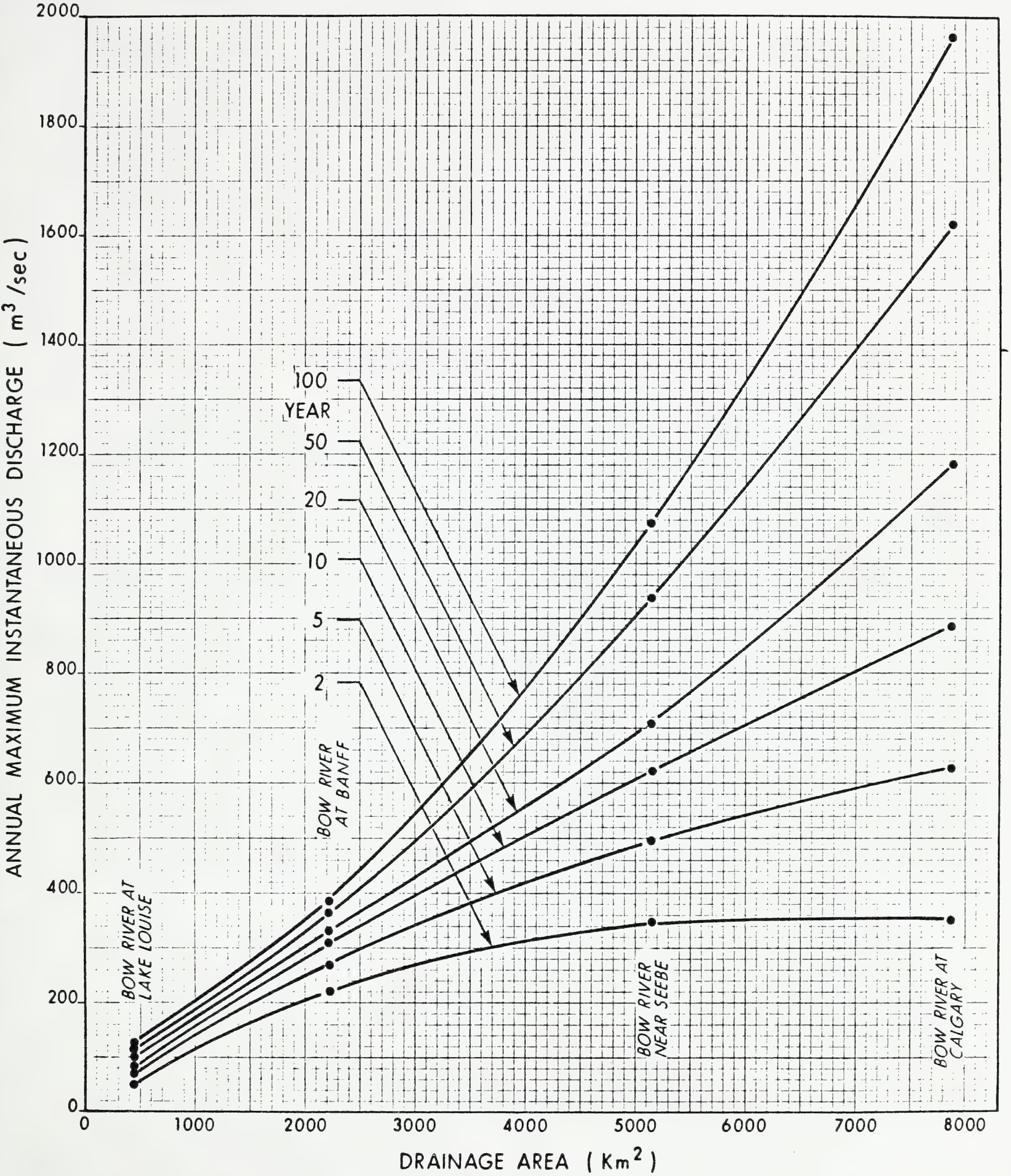
River above Jumpingpound Creek. This is accomplished by plotting the flood frequency estimates with the corresponding drainage areas, as depicted in Figure 2.5. Flood frequency estimates for Bow River near Seebe, adjusted from both the flood record at Banff, and at Calgary, provided the best fit to the overall curve shape. The minimum 1:100 year flood estimate near Seebe was rejected because this estimate gave a pronounced discontinuity between Seebe and Calgary. The maximum 1:100 year flood estimate near Seebe was rejected because this estimate gave a pronounced discontinuity between Lake Louise and Banff. The 1932 flood on the Bow River, discussed in Section 2.6, verifies the flood frequencies estimated for the Bow River near Seebe.

Table 2.5 lists the flood frequency estimates for Bow River above Jumpingpound Creek and for Bow River at Calgary, which represent the upper and lower boundaries on the Bow River for the Cochrane Floodplain Study.

2.6 The 1932 Flood

The flood of 1932 was the largest flood on the Bow River for which records are readily available and the fourth largest recorded flood at Calgary in the historical period 1879 to 1982. The return period of this flood is similar for both Bow River near Seebe and Bow River at Calgary and verifies the results of the Bow River flood frequency analysis.

Table 2.6 lists the pertinent recorded data in the Bow River basin for the 1932 flood. The peak discharge on the Bow River at Banff occurred 17 hours after the peak flow near Seebe and therefore, the June 2 mean daily flow of 207 cms is used as the contribution to down-



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	BOW RIVER FLOOD FREQUENCY ESTIMATES
SUBMITTED A.DE BOER, P. ENG. DATE DEC., 1983	DESIGNED H. BIBERHOFER, E.I.T. CHECKED	
APPROVED M. MUSTAPHA, P. ENG. DATE DEC., 1983	DRAWN V. DA SILVA CHECKED H. BIBERHOFER, E.I.T.	SCALE AS SHOWN DATE DEC., 1983
		FIGURE No. 2.5

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TABLE 2.5

FLOOD FREQUENCY ESTIMATES
BOW RIVER NEAR COCHRANE

Return Period (Years)	Annual Maximum Instantaneous Discharge (cms)	
	Bow River above Jumpingpound Creek	Bow River at Calgary
100	1590	1960
50	1340	1620
20	990	1180
10	780	882
5	580	613
2	351	351

TABLE 2.6

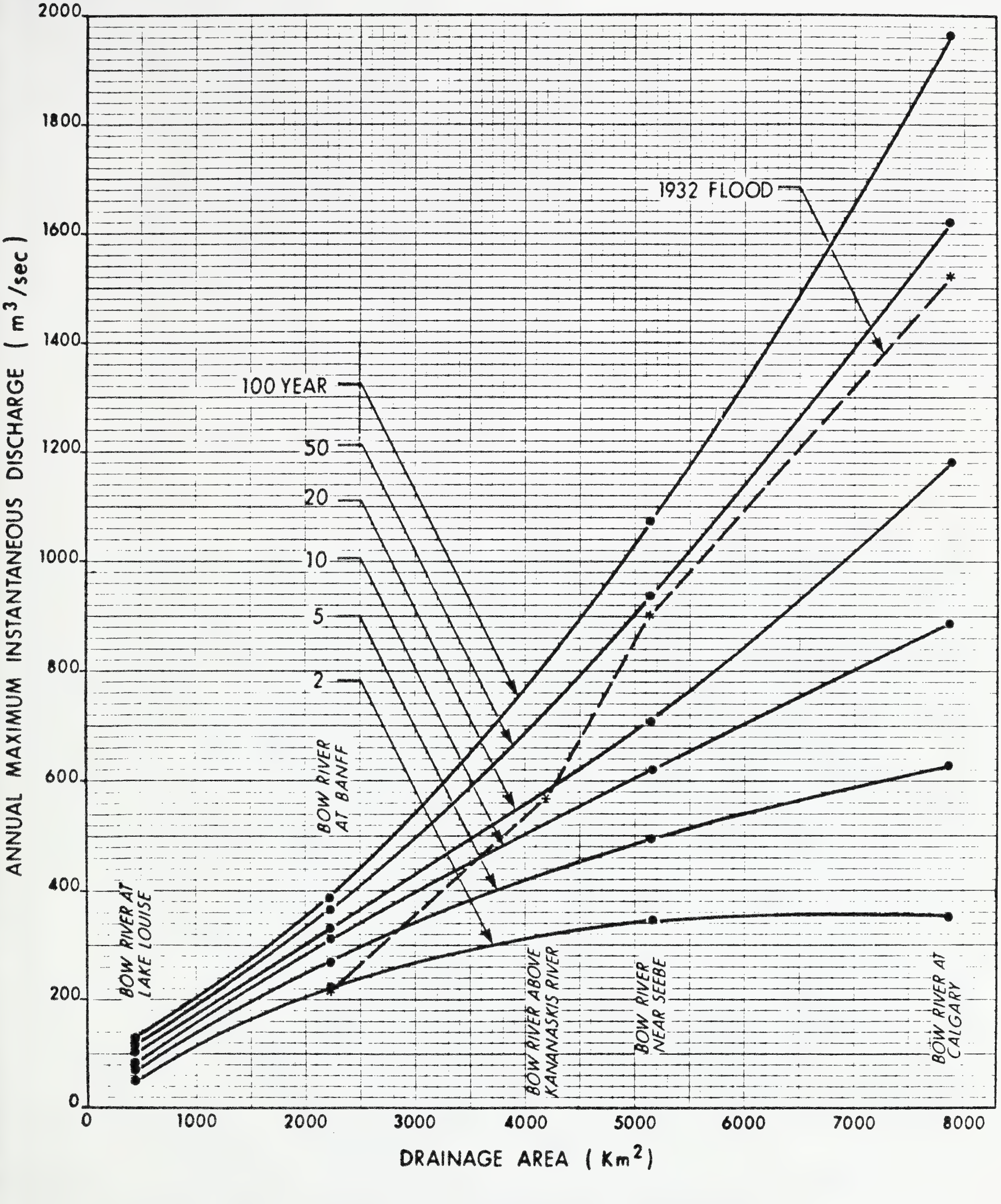
THE 1932 FLOOD EVENT

Station	Description	Area (km^2)	Instantaneous Discharge (cms)
05BB001	Bow River at Banff	2210	283 @ 08:00 on June 3
05BF001	Kananaskis River near Seebe	938	337 @ 16:30 on June 2
05BE004	Bow River near Seebe	5150	903 @ 17:00 on June 2
05BG001	Ghost River near Cochrane	909	394 @ 14:30 on June 2
05BH004	Bow River at Calgary	7870	1520 @ 02:00 on June 3

stream flood flows from the Bow River at Banff. The flow on the Bow River above the Kananaskis River (566 cms) is equal to the flow on the Bow River near Seebe (903 cms) minus the flow on the Kananaskis River near Seebe (337 cms). The 1932 flood was the largest recorded flood for the data on Kananaskis River near Seebe, Bow River near Seebe, and Ghost River near Cochrane.

Figure 2.6 compares the 1932 flood on the Bow River with the flood frequency analysis. The figure shows that the peak flow had a return period of about 1:2 years in the interior mountain zone, as represented by the Bow River at Banff. The severity of the flood increased to about a 1:15 year flood event at the transition between the interior mountain zone and the east slopes foothills zone, as represented by the Bow River above the Kananaskis River. The Bow River near Seebe is immediately downstream of the Bow River above the Kananaskis River and the contribution of the Kananaskis River increased the flood to approximately a 1:45 year event for the Bow River near Seebe. Jumpingpound Creek and the Ghost River are the major inflow sources to the Bow River between Seebe and Calgary. The 1932 flood has a return period of between 1:40 and 1:45 years for the Bow River at Calgary.

The peak flow rates per unit area, as determined from Table 2.6, are 0.359 cms per square kilometer for the Kananaskis River and 0.433 cms per square kilometer for the Ghost River and indicates a fairly uniform contribution to the 1932 flood for the area between Bow River above Kananaskis River and Bow River below Ghost River. Since the Bow River near Seebe is between the confluences of the Kananaskis River and the Ghost River, it is expected that the frequency of the 1932 flood will be similar for both Bow River near Seebe and Bow River at Calgary. This is confirmed by the Bow River flood frequency analysis.



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TECHNICAL SERVICES DIVISION
HYDROLOGY BRANCH

SUBMITTED A. DE BOER, P. ENG.
DATE DEC., 1983

DESIGNED H. BIBERHOFER, E.I.T.
CHECKED

APPROVED M. MUSTAPHA, P. ENG.
DATE DEC., 1983

DRAWN V. DA SILVA
CHECKED H. BIBERHOFER, E.I.T.

BOW RIVER 1932 FLOOD

SCALE AS SHOWN
DATE DEC., 1983

FIGURE No. 2.6

3. JUMPINGPOUND CREEK

Section 3 outlines the derivation of the annual series of maximum instantaneous discharge for Jumpingpound Creek near the Mouth. Flood frequency estimates were determined from this annual series with a Pearson Type III frequency distribution to maintain consistency with the Bow River flood frequency analysis. The coincidence of floods on Jumpingpound Creek and the Bow River is also discussed.

3.1 Annual Flood Series

Flows were recorded on Jumpingpound Creek for a period of 30 years between 1908 and 1982. Station 05BH006 - Jumpingpound Creek near Jumpingpound operated from 1908 to 1919 and in 1933. Station 05BH009 - Jumpingpound Creek near the Mouth has been in operation since 1966. These records provide the factual basis for estimating flood frequencies for Jumpingpound Creek at the Confluence of the Bow River. The area draining to station 05BH006 is 456 square kilometers, the area draining to station 05BH009 is 572 square kilometers, and the area draining to Jumpingpound Creek at the Confluence of the Bow River is 606 square kilometers.

Annual maximum daily flood flows for Jumpingpound Creek near Jumpingpound (05BH006) were transferred to Jumpingpound Creek near the Mouth (05BH009) based on an exponential relationship of the drainage area ratio raised to the power 0.8. The exponent of 0.8 is verified by a regional analysis of foothills streams in the Bow River basin[4] and is assumed applicable for the Jumpingpound Creek watershed.

For years where the maximum instantaneous discharge was not identified, estimates were obtained from a least squares fit between maximum daily (Q_D) and maximum instantaneous (Q_I) discharge. Both parameters were available in 17 years for station 05BH009. The relationship, in cms units, is given in Equation 3.1.

$$Q_I = 1.0079\ Q_D^{1.0522} \qquad \text{(Equation 3.1)}$$

The index of determination (r^2) of Equation 3.1 is 0.993. This implies that 99.3 percent of the variation in the maximum instantaneous discharges is explained by the equation. The standard error of estimate for Equation 3.1 is about 8 percent.

Table 3.1 lists the annual flood series for Jumpingpound Creek near the mouth which is used in the estimation of flood frequencies for Jumpingpound Creek at the Confluence of the Bow River.

3.2 Flood Frequency Analysis

Flood frequency estimates for Jumpingpound Creek at the Confluence of the Bow River were determined by transposing the flood frequency curve for station 05BH009 - Jumpingpound Creek near the Mouth with the exponential relationship of the drainage area ratio raised to the power 0.8. To maintain compatibility with the Bow River analysis, the Pearson Type III frequency distribution was used to assign flood probabilities. As the sample size is small, the analysis incorporates the theoretical limits of skewness. The selected limit of skewness (C_s) was 2.8 and was determined by Equation 3.2.

$$C_s = 2\ C_v/(1 - \text{Kmin}) \qquad \text{.............} \qquad \text{(Equation 3.2)}$$

TABLE 3.1

ANNUAL FLOODS OF JUMPINGPOUND CREEK

Year	05BH006 Jumpingpound Creek near Jumping Pound (daily) (cms)	05BH009 Jumpingpound Creek near the Mouth (daily) (cms)	05BH009 Jumpingpound Creek near the Mouth (instantaneous) (cms)	Date
1908	23.5	28.2 e	33.3 e	Jun 2
1909	13.9	16.7 e	19.2 e	May 24
1910	3.31	4.67 e	5.02 e	Sep 19
1911	34.0	40.8 e	40.5 e	Aug 8
1912	39.1	47.0 e	57.0 e	Jul 10
1913	22.0	26.4 e	31.1 e	Jun 27
1914	12.9	15.5 e	14.6 e	Apr 6
1915	164	196 e	256 e	Jun 26
1916	109	131 e	168 e	Sep 5
1917	142	170 e	220 e	Jun 2
1918	9.8	11.8 e	13.3 e	May 31
1919	23.5	28.2 e	33.3 e	Aug 5
1933	10.3	12.4 e	14.0 e	May 16
1966		21.2	28.3	Jul 3
1967		98.0	115	May 31
1968		20.2	23.6	Jun 9
1969		99.7	138	Jun 29
1970		71.9	91.5	Jun 14
1971		30.3	40.2	Jun 6
1972		13.5	14.6	Jun 25
1973		30.0	32.8	May 27
1974		17.5	18.1	May 27
1975		8.21	8.47	Jun 21
1976		8.07	8.98	Aug 10
1977		3.88	4.45	May 16
1978		10.4	11.3	May 17
1979		7.10	7.42	May 25
1980		22.7	24.7	Jun 4
1981		38.2	43.5	Jun 1
1982		9.77	12.4	Jun 28

The frequency curve for station 05BH009 - Jumpingpound Creek near the Mouth is shown in Figure 3.2. Table 3.2 lists the estimated flood frequencies for Jumpingpound Creek near the Mouth and at the Confluence of the Bow River.

3.3 Coincidence of Flood Peaks

The flood peak on Jumpingpound Creek near the Mouth occurred on the same day as the flood peak on Bow River at Calgary in the years 1912, 1915, 1919, 1967, and 1969 and the 1917 flood peak occurred one day before the flood peak at Calgary. Thus, in 6 of 30 years the two streams experienced coincidence of flood peaks.

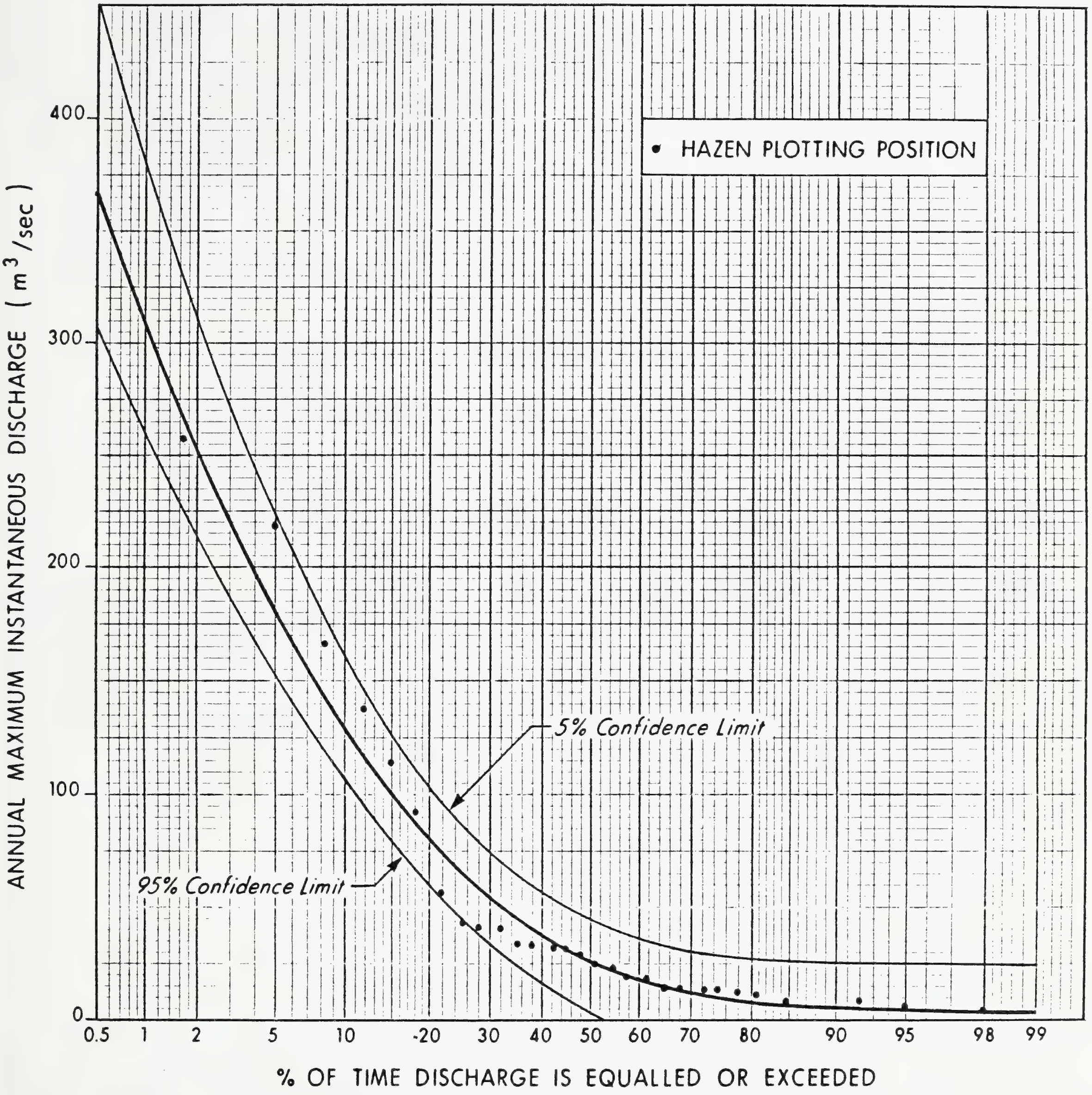
The magnitude of dependence or independence of floods between Jumpingpound Creek and the Bow River may be inferred from the Bow River flood frequency analysis. The Bow River above Jumpingpound Creek drains an area of 6,790 square kilometers, Jumpingpound Creek drains an area of 606 square kilometers, and the Bow River below Jumpingpound Creek drains an area of 7,390 square kilometers. For the 1:100 year flood event on the Bow River, the estimated flood for 7,390 square kilometers is 1790 cms and the estimated flood for 6790 square kilometers is 1590 cms. The difference of 200 cms reflects the expected contribution from Jumpingpound Creek, which represents 62 percent of the 1:100 year flood estimate of 323 cms for Jumpingpound Creek at the Confluence of the Bow River. For the 2 year flood event on the Bow River, the expected contribution from Jumpingpound Creek is negligible. However, this inference is a minimum expected contribution. The contribution of Jumpingpound Creek may be greater if the peak flow from the local area preceeds the peak flow on the Bow River. For floodplain delineation purposes, coincidence of flood peaks between the Bow River and Jumpingpound Creek should be assumed for higher return period floods.

0 10 20 30 40 50

MICROFILM DATE

DRAWING No

FILE No.



Alberta ENVIRONMENT	TECHNICAL SERVICES DIVISION **HYDROLOGY BRANCH**	FLOOD FREQUENCY CURVE 05BH009 - JUMPINGPOUND CK. NEAR THE MOUTH PEARSON TYPE III FREQUENCY DISTRIBUTION
SUBMITTED A. DE BOER, P. ENG. DATE DEC., 1983	DESIGNED H. BIBERHOFER, E.I.T. CHECKED	
APPROVED M. MUSTAPHA, P. ENG. DATE DEC., 1983	DRAWN V. DA SILVA CHECKED H. BIBERHOFER, E.I.T.	SCALE AS SHOWN DATE DEC., 1983 — **FIGURE No. 3.2**

TABLE 3.2

FLOOD FREQUENCY ESTIMATES JUMPINGPOUND CREEK

Return Period (Years)	Annual Maximum Instantaneous Discharge (cms)	
	Jumpingpound Creek near the Mouth	Jumpingpound Creek at the Confluence of the Bow River
100	308	323
50	253	265
20	181	190
10	129	135
5	80.7	84.5
2	26.1	27.3

4. BIGHILL CREEK

No streamflow measurements are available for Bighill Creek at Cochrane. Therefore, flood frequency estimates at this location must be determined by analogy with recorded flow data on neighboring streams. A field reconnaissance during the 1982 spring runoff event indicated that runoff from the Bighill Creek watershed coincided with runoff from the Beaverdam Creek and Nose Creek watersheds. Jumpingpound Creek, Elbow River and Fish Creek exhibited winter flow conditions during this period. It was concluded that the Bighill Creek watershed would exhibit runoff characteristics similar to recorded flows on prairie streams to the north and east of Cochrane rather than runoff characteristics similar to the foothills streams to the west and south of Cochrane.

4.1 Flood Frequency Estimates

A regional analysis of six prairie streams (05BM009 - Crowfoot Creek near Cluny, 05CE002 - Kneehills Creek near Drumheller, 05BH003 - Nose Creek at Calgary, 05CE005 - Rosebud River at Redland, 05CE006 - Rosebud River below Carstairs Creek, and 05CE007 - Threehills Creek near Carbon) was carried out to determine flood frequency estimates for Bighill Creek at the Confluence of the Bow River. The results were unsatisfactory due to the low index of determination and the high standard error of estimate in the correlation between contributing drainage area and the corresponding estimated flood discharge at the various frequency intervals. Therefore, flood frequency estimates for Bighill Creek were determined by analogy with the recorded data for Nose Creek at Calgary.

The Bighill Creek and Nose Creek watersheds share similar hydrometeorological conditions. Inspection of available mapping shows similarities in topographical features such as mean basin elevation, mean basin slope and amount of internal basin storage. Similarities in basin soil type and vegetation cover were confirmed by visual inspection during the field reconnaissance. Due to the close proximity of the two watersheds, similarity in climatological factors such as temperature and the intensity, distribution and quantity of precipitation may also be assumed. In summary, the processes which influence runoff (precipitation, evaporation, transpiration, interception, infiltration, percolation, and storage) are assumed similar for both the Bighill Creek and Nose Creek watersheds.

The runoff duration of floods will vary for different shapes and sizes of drainage basins because of the time required for water to reach the point of interest from the most distant location in the area contributing to runoff. This phenomenon is observed in many gauged homogeneous regions where peak flows per unit area increase as the area contributing to runoff decreases. Consequently, the duration of the runoff event will decrease for smaller watersheds if the runoff depth (the runoff volume divided by the area contributing to runoff) and the dimensionless hydrograph shape are the same for the region. The magnitude of the change in peak flow rates is determined from a regional flood frequency analysis and is expressed by the ratio of the drainage areas raised to a power. The regional analysis of prairie streams did not give statistically significant results and therefore, a drainage area ratio raised to the power 0.8 was assumed[4] for transferring peak flows from Nose Creek to Bighill Creek.

Stream gauging records for hydrometric station 05BH003 - Nose Creek at Calgary are available for the periods 1911 to 1919 and 1973 to 1982. The annual series of recorded maximum instantaneous discharge, maximum daily discharge and corresponding dates are given in Table 4.1.1.

A least squares curve fit between daily discharge and instantaneous discharge for the 7 years that recorded both parameters was completed to estimate annual maximum instantaneous discharge for those years where this parameters was not recorded. Results from this analysis were not applicable for the entire data set because the 7 data points represented only the lower range of recorded flows and could not be extrapolated to estimate the higher range of recorded flows.

An analysis of floods for Nose Creek[5] was completed by Alberta Environment in February 1980. This analysis incorporated ratios of instantaneous discharge divided by daily discharge recorded for prairie streams in the vicinity of Nose Creek. The analysis concluded that a ratio of 1.18 was representative for higher return period floods and is in agreement with the highest recorded flow in the 7 years that recorded both parameters for Nose Creek. Therefore, instantaneous flood frequency estimates for Nose Creek are determined by multiplying daily flood frequency estimates by the ratio of 1.18.

Table 4.1.2 summarizes the annual maximum instantaneous flood frequency estimates for Nose Creek at Calgary and provides the resulting flood frequency estimates for Bighill Creek at the Confluence of the Bow River. The estimates for Nose Creek are based on a drainage area of 894 square kilometers and the estimates for Bighill Creek are based on a drainage area of 174 square kilometers.

TABLE 4.1.1

ANNUAL FLOODS OF NOSE CREEK AT CALGARY

Year	Daily Flow (cms)	Date	Peak Flow (cms)	Date
1911	2.97			
1912	2.66	March 27		
1913	6.43	April 12		
1914	1.36	June 19		
1915	54.8	August 20		
1916	32.8	May 31		
1917	26.8	May 18		
1918	4.25	April 6		
1919	4.76	August 5	5.41	August 5
1973	8.10	March 22		
1974	9.32	April 10		
1975	3.31	April 13	5.21	April 13
1976	1.85	March 19	3.00	March 19
1977	0.193	March 14	0.481	April 5
1978	10.2	March 27	12.0	March 27
1979	2.28	March 8	3.23	March 7
1980	4.06	April 5	5.30	May 25
1981	2.05	July 14	5.23	July 14
1982	5.57	June 30	6.47	June 30

TABLE 4.1.2
FLOOD FREQUENCY ESTIMATES
NOSE CREEK AND BIGHILL CREEK

Return Period (Years)	Annual Maximum Instantaneous Discharge (cms)	
	Nose Creek at Calgary	Bighill Creek at the Confluence of the Bow River
100	76.9	20.8
50	62.6	16.9
20	44.2	11.9
10	30.9	8.34
5	18.6	5.02
2	5.05	1.36

4.2 Coincidence of Flood Peaks

The recorded data for Nose Creek at Calgary shows that the annual flood peaks were distributed throughout March, April, May, June, July, and August by 6, 5, 3, 2, 1, and 2 number of occurrences respectively. This indicates that the majority of the flood peaks are a result of spring snowmelt runoff. However, the three largest recorded floods on Nose Creek occurred on August 20, 1915, May 31, 1916, and May 18, 1917. This indicates that the severest floods are a result of rainfall runoff.

Flood peaks for severe flooding events at the confluence of the Bow River and Bighill Creek should be assumed coincidental for the purposes of floodplain delineation. Severe floods on the Bow River and its tributaries upstream of the City of Calgary are associated with rainfall and provides the basis for the above premise.

5. SUMMARY

Flood frequency estimates for the Bow River were derived from recorded data at Lake Louise, at Banff, near Seebe, and at Calgary. The study results, in conjunction with the study results from the Calgary Floodplain Study, indicate that diversions and reservoir regulation within the system have negligible effect in moderating major flood peaks. The 1:100 year return period flood peaks for the Bow River above the Confluence of Jumpingpound Creek and the Bow River at Calgary are estimated to be 1590 cms and 1960 cms, respectively.

Recorded natural flows are used in the analysis of Jumpingpound Creek. The 1:100 year return period flood peak for Jumpingpound Creek at the Confluence of the Bow River is estimated to be 323 cms. Coincidence of flood peaks should be assumed at this confluence for the purposes of floodplain delineation.

Peak flows for Bighill Creek are based on an analogy with recorded flows for Nose Creek. A 1:100 year return period peak flow of 20.8 cms was estimated for Bighill Creek at the Confluence of the Bow River. Coincidence of flood peaks should also be assumed at this confluence for floodplain delineation studies.

REFERENCES

1. DeBoer, A., Hydrologic Analysis, Calgary Floodplain Study, Alberta Environment, Hydrology Branch, Edmonton, 1983.

2. Kite, G.W., Frequency and Risk Analysis in Hydrology, Inland Waters Directorate, Water Resources Branch, Applied Hydrology Division, Ottawa, 1976.

3. Montreal Engineering Company Limited, City of Calgary Flood Study, May, 1973.

4. Ashraf, M., Draft Report - Bow River Basin, Foothills Region, Regional Flood Frequency Analysis, Alberta Environment, Hydrology Branch, Edmonton, 1982.

5. Kerr, W.E., Analysis of Floods - Nose Creek, Alberta Environment, Hydrology Branch, Edmonton, 1980.

CONVERSIONS

Metric to English

m^3/sec	times	35.315	equals	cfs
km^2	times	0.3861	equals	mi^2
m^3	times	.000409	equals	cfs days
meters	times	3.281	equals	feet
m^3/sec/km^2	times	91.5	equals	cfs/mi^2

APPENDIX A

HISTORICAL FREQUENCY ANALYSIS

HISTORICAL FREQUENCY ANALYSIS

Information on major floods that occurred prior to the start of a systematic record can often be used to improve frequency estimates. In such a situation, the following procedures are used to compute an historically weighted Pearson III frequency curve.

Historic knowledge is used to define the historically longer period of "H" years. The number "Z" of events that are known to be the largest in the period "H" are given a weight of 1.0. The remaining "N" events from the systematic record are given a weight of (H-Z)/N on the assumption that their distribution represents the (H-Z) remaining years of the historically longer period.

The computations are done by applying the weights to each individual year's data using the following equations.

$$W = \frac{H - Z}{N}$$

$$M = \frac{W \Sigma X + \Sigma X_z}{H}$$

$$S^2 = \frac{W \Sigma (X - M)^2 + \Sigma (X_z - M)^2}{(H - 1)}$$

$$G = \frac{H}{(H - 1) \quad (H - 2)} \quad \frac{W \Sigma (X - M)^3 + \Sigma (X_z - M)^3}{S^3}$$

$$Q = M + KS$$

Where X = annual peak flow.

X_2 = historic peak flow.

N = number of events in systematic record being used.

M = historically weighted mean.

S = historically weighted standard deviation.

G = historically weighted skew coefficient.

K = Pearson III coordinate expressed in number of standard deviations from the mean for a specified recurrence interval.

The plotting positions for the individual flood events are computed as follows:

$$m = E \text{ when } 1 \leq E \leq Z$$

$$m = WE - (W-1)(Z+0.5) \text{ when } (Z+1) \leq E \leq (Z+N)$$

$$pp = \frac{m - a}{H+1-2a} 100$$

Where m = weighted order number of each event for use in formulas to compute plotting position.

E = event number when events are ranked in order from greatest magnitude to smallest magnitude.

a = constant that is characteristic of a given plotting position formula. For Hazen; $a = 0.5$; for Weibull, $a = 0$.

APPENDIX C
1981 Highwater Mark Survey

1981 HIGHWATER MARK SURVEY

A highwater mark survey was undertaken by the River Engineering Branch, Alberta Environment following the May 28, 1981 peak on the Bow River at Cochrane. The maximum instantaneous discharge for this flood was estimated to be in the order of 422 m^3/s downstream of Jumpingpound Creek. This estimate was made by summing the maximum instantaneous peak discharge (406 m^3/s) for the Bow River below Ghost Dam (Station No. 05BE006) and the mean daily discharge (16.3 m^3/s) for Jumpingpound Creek near the mouth (Station No. 05BH009).

The results of the highwater mark survey are summarized in Table C-1. The locations of the 5 monitoring sites are shown on Figure C-1.

TABLE C-1

Summary: 1981 Highwater Mark Survey
Bow River at Cochrane

Site No.	Description	Elevation*
B081-1	Highway 22 Bridge (Left Bank)	
	10 m u/s of u/s side	1120.39
	10 m d/s of d/s side	1120.19
	72 m d/s of d/s side	1120.08
	76 m d/s of d/s side	1119.98
B081-2	River Avenue Bridge (Left Bank)	
	103 m u/s of u/s side	1115.93
	10 m u/s of u/s side	1116.03
	10 m d/s of d/s side	1115.79
	124 m d/s of d/s side	1115.44
B081-3	SW 35-25-4-W5 (Left Bank) In line with west fence line of Cochrane Sewage Lagoons	1113.42
B081-4	NW 35-25-4-W5 (Left Bank) Directly east of NE corner of large barn	1112.24

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* Elevations are given in metres (Geodetic Survey)

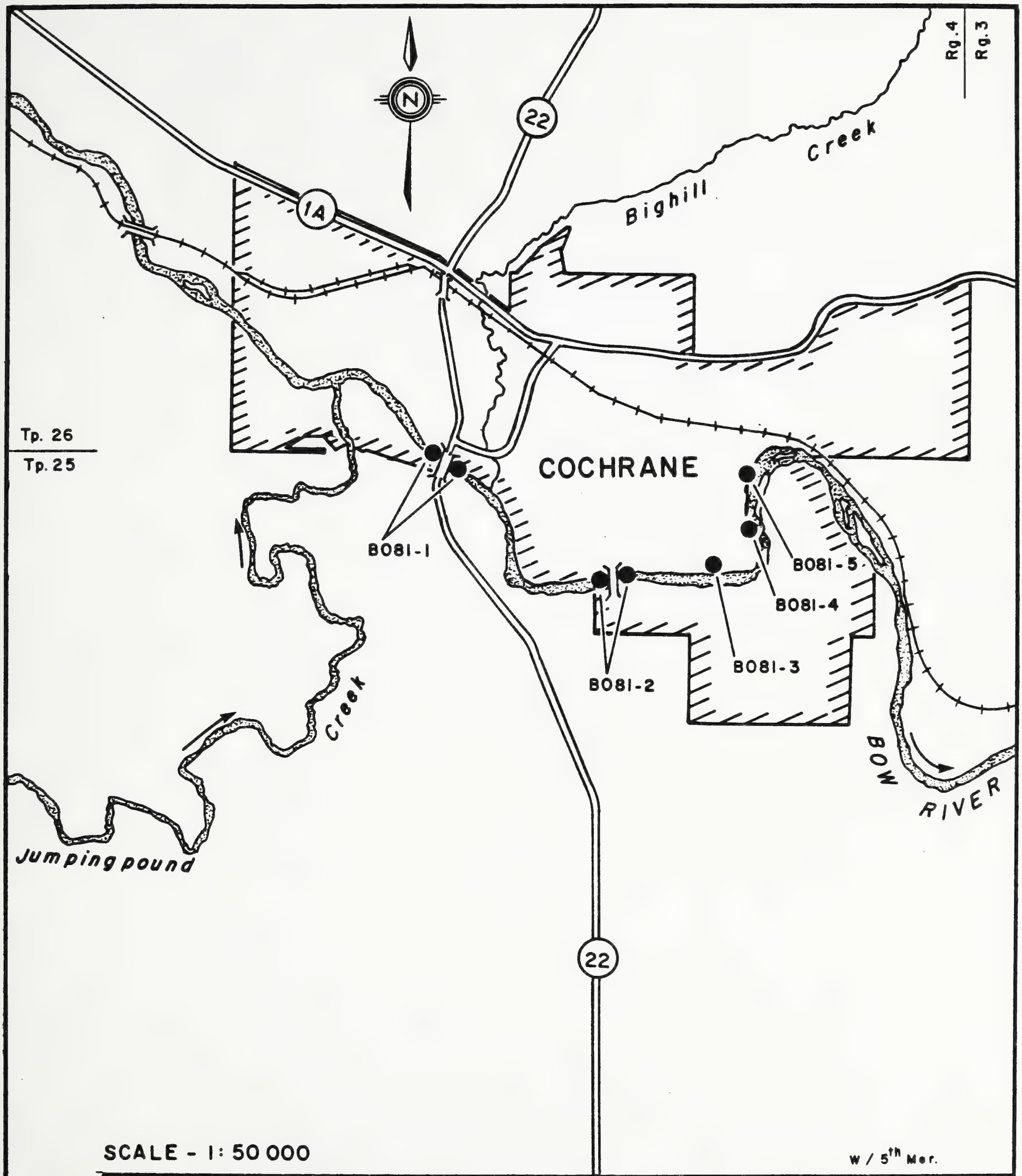
TABLE C-1 (Cont'd)

Summary: 1981 Highwater Mark Survey
Bow River at Cochrane

Site No.	Description	Elevation*
B081-5	NW 35-25-4-W5 (Left Bank) Directly east of SW corner of coral	1111.47

---

* Elevations are given in metres (Geodetic Survey).



Alberta
ENVIRONMENT

Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

MONITORING SITES
1981 HIGHWATER MARK SURVEY

DRAWN BY: E. Bemlancey
CHECKED BY: T. Wintoly
APPROVED BY: M. Cheraghi
DATE: June 17/86

FIGURE No. C-1

APPENDIX D
Ice Pack Observations and Analysis

ICE PACK OBSERVATIONS AND ANALYSIS

1981-82 Ice Pack Survey

The results of the 1981-82 ice pack survey (Alberta Environment) on the Bow River near Cochrane are summarized below in Table D-1. The locations of the 8 monitoring sites are shown on Figure D-1.

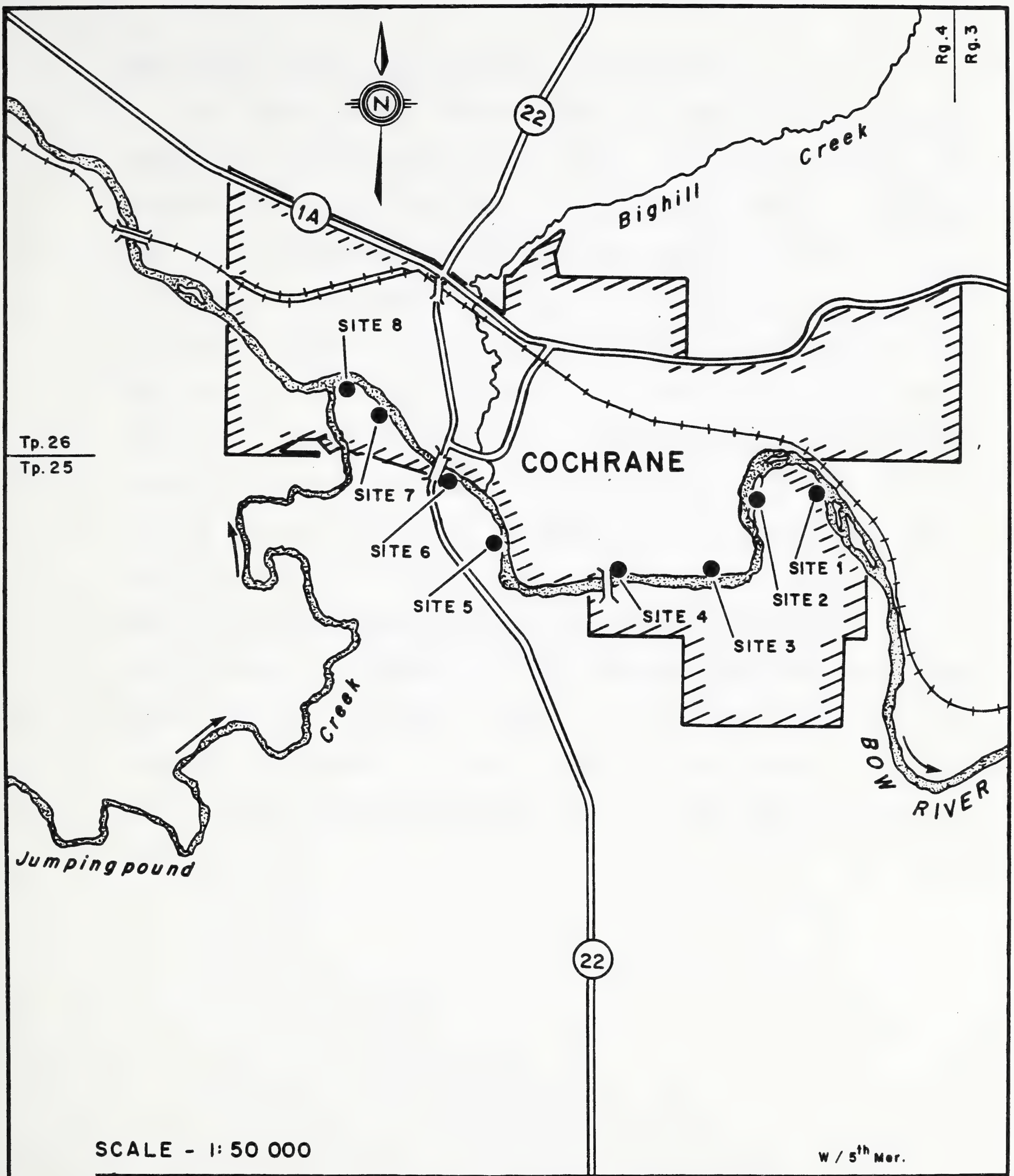
TABLE D-1

Summary: 1981-82 Ice Pack Survey

Site No.	December 15, 1981 Water Level	Ice Level	January 25, 1982 Water Level	Ice Level	February 22, 1982 Water Level	Ice Level
1	1108.01	A	1109.50	1110.93*	1109.88	1110.87
2	1110.34	A	1112.99	1113.88*	1113.31	1113.82
3	1112.65	A	1115.29	1116.21*	1114.84	1116.08
4	1114.78	A	1117.30	1118.17*	1116.88	1117.93
5	B	A	B	B	1118.99	1120.34*
6	1118.71	A	1121.36	1122.32	1120.90	1122.33*
7	B	A	B	B	1122.53	1124.52*
8	B	A	B	B	1123.30	1125.16*

A - Ice cover not formed
B - Measurement not taken
* - Highest ice level for year

Note: All elevations are given in metres (Geodetic Survey)



Alberta
ENVIRONMENT

Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

MONITORING SITES
1981 - 82 ICE PACK SURVEY

DRAWN BY:
APPROVED BY:
CHECKED BY:
DATE: June 17/86

FIGURE No. D - 1

Analysis of Winter Stages at the River Avenue Bridge

The annual maximum winter stage (ice induced water levels) observations at the River Avenue Bridge (Old Cochrane Bridge) are presented in Table D-2 for the period of record 1947-48 to 1982-83. Stage frequency estimates for this site were determined by analysing the 18 years of actual data. Years for which no winter stage data is available, or where the ice pack did not reach Cochrane, were excluded from the analysis. The data sample is from the period following installation of the Ghost Dam and is assumed to be a representative sample of homogeneous events.

The Pearson III and the log-normal frequency distributions were used to assign the flood probabilities. Figure D-2 presents the computed frequency curves along with the Hazen plotting positions for the data sample. The Pearson III distribution fitted the plotted data points better in the upper range of the frequency curve and was therefore selected for this study. Table 5.1 (Main Report) lists the estimated winter stage frequencies for the River Avenue Bridge at Cochrane.

TABLE D-2

Maximum Observed Winter Stage at the River Avenue Bridge

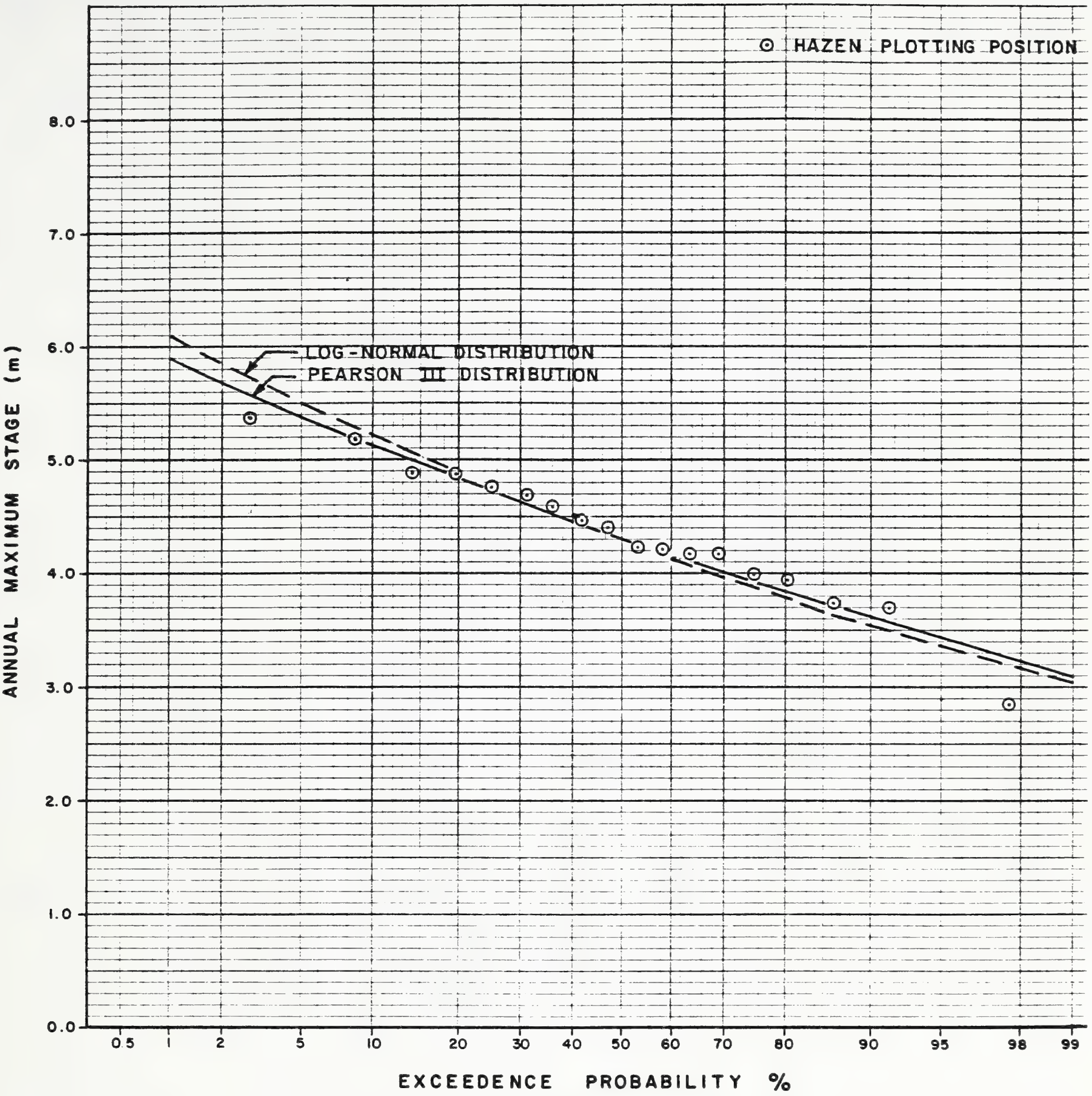
Year	Stage[1] (m)	Year	Stage (m)
1947-48	A	1965-66	B
1948-49	1118.48	1966-67	A
1949-50	1116.83	1967-68	1117.72
1950-51	B	1968-69	1118.39
1951-52	A	1969-70	B
1952-53	A	1970-71	1119.18
1953-54	1117.96	1971-72	1118.72
1954-55	B	1972-73	1119.36
1955-56	1118.17	1973-74	1118.23
1956-57	B	1974-75	1117.99
1957-58	B	1975-76	A
1958-59	1118.87	1976-77	A
1959-60	B	1977-78	1117.75
1960-61	B	1978-79	1118.78
1961-62	1118.90	1979-80	A
1962-63	1118.60	1980-81	B
1963-64	B	1981-82	1118.17
1964-65	1118.23	1982-83	A

---

[1] Stage is the maximum ice induced flood level

A - Year in which the ice pack did not reach Cochrane
B - Year for which no observations were recorded.

Note: The data in Table D-2 (except for the years 1981-82 and 1982-83) was obtained from records provided by TransAlta Utilities Corporation.



NOTE : DATUM FOR STAGE = ELEVATION 1114.0 m (Geodetic Survey)

Alberta
ENVIRONMENT
Water Resources Management Service
Technical Services Division

COCHRANE FLOODPLAIN STUDY

WINTER STAGE FREQUENCY CURVES
FOR THE BOW RIVER AT
THE RIVER AVENUE BRIDGE

DRAWN BY : C. Fort
APPROVED BY :
CHECKED BY :
DATE : June 17/86

FIGURE No. D-2

APPENDIX E

HEC-2 MODEL INPUT/OUTPUT

```
1*******************************************************                            ****************************************
 *  WATER SURFACE PROFILES                               *                               *  U.S. ARMY CORPS OF ENGINEERS
 *
 *  VERSION OF NOVEMBER 1976                             *                               *  THE HYDROLOGIC ENGINEERING CENTER
 *
 *  UPDATED MAY 1984                                     *                               *  609 SECOND STREET, SUITE D
 *
 *  IBM-PC-XT VERSION AUGUST 1985                        *                               *  DAVIS, CALIFORNIA 95616
 *
 *  RUN DATE  11-27-90   TIME  12:49:48                    *                               *  (916) 440-2105 (FTS) 448-2105
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                                              X     X  X        X                       X
                                              XXXXXXX  XXXX     X         XXXXX    XXXXX
                                              X     X  X        X                 X
                                              X     X  X        X     X           X
                                              X     X  XXXXXXX   XXXXX            XXXXXXX
1
  11-27-90     12:49:48                                                                                            PAGE    1


                                                                                   THIS RUN EXECUTED 11-27-90
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   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ****************************************************


T1      COCHRANE FLOODPLAIN STUDY        FILENAME=COCHBOW1       "FINAL"
T2      BEARSPAW RESERVOIR TO UPSTREAM OF COCHRANE
T3      BOW RIVER                        1:100 YEAR FLOOD        N=0.026

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0.        0.        0.        0.   .000000      1.00        .0     1960.  1090.600      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

    -1.000      .000    -1.000      .000      .000     -.867      .000      .000      .000      .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

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     1.000   150.000      .000      .000      .000      .000      .000      .000      .000      .000

J6  IHLEQ     ICOPY

     1.000      .000      .000      .000      .000      .000      .000      .000      .000      .000


NC       .000       .000       .030       .100       .300       .000       .000       .000       .000       .000
NH      4.000       .040    212.000       .030    507.770       .040    513.500       .125    539.380       .000
X1      1.000     66.000    212.000    507.770       .000       .000       .000       .000       .000       .000
GR   1100.800       .000   1099.500     26.800   1098.800     40.300   1097.800     46.600   1096.800     73.100
GR   1096.200     99.900   1095.900    133.400   1095.800    174.300   1096.100    201.100   1095.500    202.300
GR   1094.600    206.300   1091.200    212.000   1091.200    212.100   1089.300    213.660   1088.200    216.680
GR   1086.700    224.740   1086.400    230.780   1086.200    237.830   1086.200    243.870   1086.400    250.920
GR   1086.500    256.960   1086.600    273.070   1086.600    286.160   1086.600    293.210   1086.600    309.320
GR   1086.800    314.360   1086.700    318.390   1086.900    323.420   1088.300    329.460   1089.100    333.490
GR   1089.300    340.540   1089.200    347.590   1089.100    353.630   1088.500    360.680   1088.600    371.760
GR   1088.400    378.810   1088.400    383.840   1087.600    390.890   1087.600    392.910   1087.700    395.930
GR   1087.600    397.940   1087.900    398.950   1088.600    401.970   1089.300    402.980   1089.600    407.000
GR   1089.200    420.100   1088.900    434.190   1088.700    436.210   1088.900    439.230   1088.900    443.260
GR   1089.100    455.340   1089.000    458.360   1089.200    465.410   1088.300    474.470   1088.500    477.490
GR   1088.900    480.520   1089.200    487.560   1089.400    497.630   1089.600    504.770   1090.400    507.770
GR   1090.600    508.600   1090.900    508.800   1092.600    513.500   1094.300    519.500   1106.500    538.500
GR   1106.800    539.380       .000       .000       .000       .000       .000       .000       .000       .000
1
  11-27-90     12:49:48                                                                                            PAGE    2


NH      4.000       .040     59.040       .030    371.290       .040    375.740       .125    393.870       .000
X1      2.000     53.000     61.500    386.760    410.000    410.000    410.000       .960       .000       .000
GR   1099.600       .000   1098.400     13.300   1094.400     28.500   1092.900     41.600   1092.500     54.100
GR   1091.400     61.100   1090.800     61.500   1090.400     62.310   1089.800     63.310   1089.800     67.990
GR   1089.300     71.890   1088.400     77.350   1087.300     79.690   1087.200     90.610   1087.000     96.070
GR   1087.100     97.630   1087.000    102.310   1086.900    106.210   1086.900    113.230   1086.800    120.250
GR   1087.100    129.610   1086.900    132.730   1086.900    141.310   1086.700    150.670   1086.600    159.250
GR   1086.600    167.830   1086.800    172.510   1088.200    177.970   1088.800    185.770   1089.500    193.570
GR   1089.700    200.590   1089.600    207.700   1089.800    210.700   1090.400    219.800   1090.200    226.300
GR   1090.400    234.700   1090.400    240.210   1090.400    243.900   1090.600    254.500   1090.500    264.500
GR   1090.200    290.500   1090.200    332.100   1089.800    345.900   1090.000    361.100   1089.600    371.700
GR   1089.600    383.700   1090.500    386.760   1091.200    387.400   1094.100    391.400   1098.300    394.300
GR   1100.200    396.800   1107.000    408.900   1107.300    410.280       .000       .000       .000       .000

NH      4.000       .040    104.300       .030    207.000       .040    337.200       .125    424.940       .000
X1      3.000     52.000    104.300    207.000    325.000    325.000    325.000       .000       .000       .000
GR   1099.900       .000   1098.700     38.400   1098.000     67.300   1097.400     91.000   1097.700     95.840
GR   1097.300     98.840   1091.700    104.300   1090.600    105.440   1089.900    106.440   1089.600    107.750
GR   1088.100    110.360   1086.400    114.930   1086.700    117.540   1086.800    122.110   1086.800    129.950
GR   1087.000    133.870   1087.200    137.130   1087.400    143.010   1087.400    149.540   1087.500    154.760
GR   1087.600    158.680   1087.700    162.600   1087.700    168.480   1088.900    179.580   1089.100    184.150
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GR  1089.200   190.020  1089.600   194.600  1089.800   200.470  1089.700   205.000  1090.100   207.000
GR  1090.200   216.800  1090.100   223.700  1090.200   242.000  1090.500   251.900  1090.000   260.200
GR  1089.900   265.600  1090.300   272.700  1090.600   290.480  1090.500   293.100  1090.500   296.240
GR  1090.400   296.600  1090.400   298.600  1090.500   300.460  1090.700   314.100  1091.200   337.200
GR  1091.000   358.700  1090.900   366.700  1091.900   376.200  1091.900   393.300  1101.100   411.500
GR  1106.900   422.000  1107.900   424.940      .000      .000      .000      .000      .000      .000

NH     4.000      .050   264.900      .030   378.740      .040   380.900      .125   394.450      .000
X1     4.000    48.000   264.900   378.740   710.000   690.000   720.000      .000      .000      .000
GR  1106.800      .000  1101.700    60.900  1099.400   101.600  1093.200   117.800  1092.200   165.800
GR  1092.400   176.400  1092.000   203.600  1092.100   238.700  1092.300   263.000  1092.200   263.060
GR  1092.100   263.100  1091.500   264.900  1090.600   271.290  1090.000   274.290  1089.900   281.610
GR  1089.600   286.110  1089.400   288.360  1089.000   290.620  1088.000   292.310  1088.600   295.680
GR  1088.400   299.620  1088.600   303.000  1088.800   307.510  1088.700   313.140  1088.800   317.080
GR  1089.100   322.140  1089.000   326.090  1089.000   332.280  1089.100   333.970  1089.000   336.780
GR  1089.100   341.850  1088.900   349.170  1088.700   355.360  1088.600   358.740  1088.600   361.560
GR  1088.400   363.810  1088.200   364.930  1088.200   367.750  1088.500   371.130  1089.200   374.500
GR  1089.600   376.240  1090.600   378.740  1092.400   380.900  1093.400   381.900  1100.000   387.300
GR  1105.600   390.400  1106.900   391.900  1107.400   394.450      .000      .000      .000      .000

NH     6.000      .040    72.700      .100   155.900      .040   255.600      .030   364.710      .040
NH   367.000      .125   387.320      .000      .000      .000      .000      .000      .000      .000
X1     5.000    44.000   255.600   364.710   200.000   180.000   185.000      .000      .000      .000
GR  1107.000      .000  1105.100    10.800  1100.100    24.400  1094.800    43.800  1092.300    63.600
GR  1093.000    72.700  1092.800    95.200  1092.900   132.100  1093.000   155.900  1093.300   184.700
GR  1092.300   198.500  1091.900   223.600  1092.100   236.500  1092.300   252.600  1093.100   253.100
GR  1092.600   255.200  1090.800   255.600  1090.900   259.430  1089.500   261.430  1089.500   262.850
GR  1089.300   265.700  1089.200   269.250  1089.300   274.940  1089.300   279.200  1089.100   285.600
GR  1088.800   293.420  1088.700   297.690  1088.700   301.960  1088.600   311.910  1088.600   321.150
GR  1088.500   330.400  1088.300   337.510  1088.300   341.770  1088.100   346.750  1088.400   350.300
GR  1088.800   353.860  1089.300   358.840  1089.400   361.710  1090.400   364.710  1091.600   366.100
GR  1092.600   367.000  1102.200   378.800  1107.300   385.700  1107.400   387.320      .000      .000
1
 11-27-90     12:49:48                                                                              PAGE     3


NH     4.000      .050   171.800      .030   331.400      .040   334.900      .125   344.570      .000
X1     6.000    50.000   171.800   331.400   480.000   550.000   530.000      .000      .000      .000
GR  1109.600      .000  1103.300    11.100  1093.700    27.400  1092.800    28.800  1093.200    44.900
GR  1093.400    95.000  1093.200   138.000  1093.600   170.800  1093.100   171.600  1092.600   171.800
GR  1090.700   177.010  1090.200   182.000  1090.100   184.300  1090.100   189.600  1090.000   192.600
GR  1089.900   194.800  1089.700   197.900  1089.800   203.200  1090.100   206.900  1090.200   209.200
GR  1090.700   210.200  1091.300   212.700  1091.500   225.300  1092.300   244.400  1092.300   255.100
GR  1092.200   264.000  1091.500   269.400  1090.900   271.690  1090.300   279.700  1089.500   284.200
GR  1088.700   289.100  1088.700   291.300  1088.800   292.300  1088.700   294.100  1088.500   298.800
GR  1088.300   304.100  1088.300   306.500  1088.300   307.500  1088.300   310.500  1088.400   313.000
GR  1089.400   318.500  1090.000   321.400  1090.200   324.900  1090.400   328.900  1090.900   331.400
GR  1093.700   334.900  1097.400   337.800  1098.800   340.400  1101.000   341.400  1102.000   344.570

NH     4.000      .040    46.850      .030   143.500      .040   160.800      .100   648.720      .000
X1     7.000    47.000    48.800   149.480   590.000   480.000   530.000      .960      .000      .000
GR  1113.800      .000  1113.500     1.000  1102.200    16.100  1100.500    21.500  1099.700    24.300
GR  1099.700    37.300  1094.300    44.300  1092.500    46.100  1091.900    48.800  1091.500    49.800
GR  1090.700    53.800  1090.600    57.180  1090.300    62.580  1090.400    68.650  1090.400    72.700
GR  1090.600    77.420  1090.800    82.820  1090.900    90.920  1090.900    94.980  1090.800    99.700
GR  1091.000   103.080  1090.900   104.420  1090.400   108.480  1090.600   111.750  1090.700   115.220
GR  1090.600   118.600  1090.300   122.650  1090.200   126.700  1090.100   132.100  1090.400   137.500
GR  1090.600   140.200  1090.800   144.920  1090.700   146.980  1091.500   149.480  1092.000   150.500
GR  1092.600   155.600  1093.400   158.000  1094.000   164.300  1093.900   167.500  1094.100   169.700
GR  1094.400   178.600  1096.800   187.200  1097.700   191.200  1098.100   206.800  1099.200   234.700
GR  1103.100   301.100  1156.400   713.250      .000      .000      .000      .000      .000      .000

NH     4.000      .050   234.250      .030   310.280      .040   311.320      .125   521.470      .000
X1     8.000    43.000   249.200   330.090   640.000   470.000   540.000      .940      .000      .000
GR  1109.300      .000  1109.300     1.000  1097.800    20.900  1097.100    61.500  1096.600    99.200
GR  1096.300   127.900  1096.400   153.100  1095.000   166.300  1094.900   185.700  1094.500   204.800
GR  1095.000   210.400  1094.700   230.100  1095.500   247.400  1095.300   248.500  1094.700   249.200
GR  1092.500   253.980  1092.000   255.480  1092.000   257.880  1091.800   262.210  1091.400   267.500
GR  1091.100   270.390  1090.800   272.320  1090.800   273.760  1090.800   277.120  1090.700   279.050
GR  1090.700   284.340  1090.700   289.150  1090.700   292.040  1090.700   296.850  1090.700   302.140
GR  1090.800   306.950  1090.800   309.830  1091.000   314.640  1091.000   316.570  1090.000   318.490
GR  1091.000   321.380  1091.100   324.260  1091.400   326.190  1091.700   327.590  1092.500   330.090
GR  1095.400   331.200  1107.100   347.800  1155.600   554.750      .000      .000      .000      .000

NH     4.000      .050   157.600      .030   279.450      .040   282.400      .125   315.440      .000
X1     9.000    43.000   157.600   279.450   380.000   380.000   380.000      .000      .000      .000
GR  1104.900      .000  1102.800    17.500  1100.600    28.500  1098.700    36.600  1098.400    67.900
GR  1098.300   100.800  1097.800   123.200  1095.200   142.600  1095.300   149.100  1095.200   153.200
GR  1094.200   157.600  1093.700   174.100  1093.600   197.700  1092.800   224.250  1092.000   226.250
GR  1092.100   227.470  1092.000   229.920  1091.700   232.370  1091.500   235.230  1091.200   238.080
GR  1091.300   240.120  1090.800   244.200  1090.800   246.650  1090.700   247.870  1090.800   249.510
GR  1090.700   251.550  1090.800   252.770  1090.600   253.990  1090.800   258.480  1090.800   259.710
GR  1090.900   260.520  1091.200   262.970  1091.300   267.050  1091.700   270.310  1091.600   271.130
GR  1091.700   274.390  1091.800   276.450  1092.800   279.450  1095.500   282.400  1098.800   285.900
GR  1102.100   288.400  1105.000   292.900  1155.700   315.440      .000      .000      .000      .000
1
 11-27-90     12:49:48                                                                              PAGE     4


NH     4.000      .040    90.820      .030   181.170      .040   237.310      .125   478.030      .000
X1    10.000    41.000    94.600   188.720   360.000   410.000   400.000      .960      .000      .000
X2  1950.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
GR  1106.600      .000  1104.700    30.200  1102.900    58.200  1100.400    86.000  1096.800    91.500
GR  1094.500    94.600  1093.800    95.900  1093.200    97.400  1093.000   102.100  1092.900   107.270
GR  1093.000   109.620  1092.900   113.380  1092.900   114.320  1092.900   115.730  1092.600   120.430
GR  1092.600   124.660  1092.500   130.300  1092.400   135.470  1092.300   141.580  1092.200   145.340
GR  1092.300   152.390  1092.200   154.740  1092.300   156.150  1092.300   158.500  1092.400   160.380
GR  1092.300   161.790  1092.600   164.610  1092.600   169.310  1092.600   171.190  1092.900   174.950
GR  1093.000   178.710  1093.100   180.590  1093.200   185.720  1093.800   188.720  1093.900   189.700
GR  1095.900   193.800  1096.400   198.800  1096.700   247.200  1096.600   380.770  1127.500   411.430
GR  1163.100   497.950      .000      .000      .000      .000      .000      .000      .000      .000

NH     4.000      .040   130.400      .030   290.600      .040   296.300      .100   438.610      .000
X1    11.000    59.000   130.400   290.600   460.000   570.000   510.000      .000      .000      .000
GR  1112.500      .000  1111.800     6.500  1108.300    20.900  1105.700    36.300  1103.500    56.400
GR  1099.400    70.100  1099.200   101.900  1099.200   126.500  1098.000   127.700  1099.000   129.100
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GR  1097.500   130.400  1094.300   133.400  1095.000   134.350  1094.300   136.400  1094.300   140.700
GR  1094.400   143.200  1094.100   148.500  1094.000   149.200  1094.200   152.800  1094.400   156.300
GR  1094.400   160.200  1094.300   164.500  1094.300   168.000  1094.300   169.100  1095.000   172.090
GR  1095.000   173.000  1095.400   173.910  1095.400   180.000  1095.200   180.390  1094.600   185.400
GR  1094.500   191.900  1094.600   198.300  1094.500   205.200  1094.400   211.200  1094.400   215.100
GR  1094.500   218.100  1094.500   224.600  1094.500   240.100  1094.400   244.000  1094.600   246.100
GR  1094.200   249.200  1094.400   254.300  1094.600   259.100  1094.500   265.100  1094.200   272.000
GR  1094.500   277.200  1094.500   281.900  1094.600   286.200  1095.200   288.250  1095.500   289.700
GR  1096.000   290.600  1095.800   294.200  1098.300   296.300  1098.700   366.500  1103.800   380.300
GR  1105.900   398.000  1113.500   430.600  1113.800   435.300  1114.100   438.610      .000      .000

NH     5.000      .040   239.900      .030   339.960      .040   342.800      .125   353.150      .040
NH   388.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1    12.000    71.000   239.900   339.960   360.000   370.000   370.000      .000      .000      .000
GR  1109.400      .000  1107.200    31.600  1106.400    50.800  1105.600    60.100  1101.200    77.600
GR  1100.200    98.500  1100.000   126.100  1099.000   133.800  1096.500   138.700  1095.800   142.100
GR  1095.400   147.700  1095.800   150.600  1096.600   153.800  1097.100   183.400  1096.600   188.000
GR  1096.600   190.500  1096.900   192.600  1097.300   201.700  1097.500   222.400  1097.800   236.600
GR  1096.300   239.900  1095.900   241.680  1095.400   244.680  1095.400   246.420  1095.100   248.600
GR  1094.900   252.960  1094.900   255.580  1095.000   257.320  1095.100   258.630  1094.900   261.250
GR  1094.900   265.170  1094.900   267.790  1094.800   269.100  1094.800   271.100  1094.700   272.400
GR  1094.800   275.100  1094.800   277.200  1094.900   278.500  1094.800   279.400  1094.800   281.100
GR  1094.800   282.400  1094.900   284.200  1095.000   287.200  1095.000   293.300  1094.800   298.900
GR  1094.800   301.100  1094.700   302.400  1094.800   304.100  1094.700   306.300  1094.700   308.000
GR  1094.600   309.800  1094.700   311.900  1094.600   314.100  1094.600   316.300  1094.600   317.600
GR  1094.500   322.800  1094.300   326.700  1094.400   331.500  1094.500   333.600  1095.000   337.960
GR  1095.900   339.960  1096.300   340.600  1099.000   342.500  1099.100   342.800  1100.400   344.700
GR  1102.800   347.800  1103.600   348.100  1104.200   348.700  1105.800   352.200  1106.000   353.150
GR  1108.400   388.000      .000      .000      .000      .000      .000      .000      .000      .000

NH     4.000      .040   298.200      .030   391.570      .040   396.200      .125   415.990      .000
X1    13.000    45.000   298.200   391.570   510.000   550.000   530.000      .000      .000      .000
GR  1114.300      .000  1112.600    14.300  1110.800    32.300  1105.700    53.700  1104.500    82.800
GR  1103.600   122.200  1102.700   157.000  1101.600   192.800  1100.800   229.300  1100.100   269.400
GR  1097.600   275.900  1096.800   298.200  1096.400   302.200  1095.700   307.200  1095.700   318.300
GR  1095.900   326.100  1096.100   330.300  1096.100   330.700  1096.000   332.700  1095.700   338.900
1
 11-27-90      12:49:48                                                                      PAGE     5


GR  1095.600   341.000  1095.400   344.300  1095.200   347.600  1094.900   355.800  1094.800   358.300
GR  1094.900   360.700  1094.800   362.400  1094.700   365.700  1094.900   371.100  1094.900   376.800
GR  1095.100   381.300  1095.300   383.800  1095.600   386.700  1095.800   389.570  1096.400   391.570
GR  1096.900   393.500  1098.400   394.100  1100.300   396.200  1101.700   398.200  1102.800   398.400
GR  1103.600   399.200  1108.500   405.400  1112.900   409.000  1115.700   414.500  1116.200   415.990

NH     4.000      .040   142.900      .030   278.820      .040   282.900      .125   307.400      .000
X1    14.000    55.000   142.900   278.820   325.000   325.000   325.000      .000      .000      .000
GR  1105.200      .000  1106.700    38.200  1105.100    61.300  1102.300    73.900  1101.200    98.800
GR  1100.500   118.700  1100.500   138.400  1099.600   139.300  1097.600   142.900  1097.200   143.830
GR  1096.600   146.300  1096.400   148.400  1096.500   150.600  1096.300   158.000  1096.500   160.100
GR  1096.700   162.300  1096.600   170.800  1096.500   172.900  1096.500   175.600  1096.600   179.300
GR  1096.500   186.800  1096.500   191.600  1096.400   195.300  1096.400   197.400  1096.500   199.600
GR  1096.600   210.200  1097.000   216.500  1097.200   220.190  1097.300   224.800  1097.300   232.700
GR  1097.000   238.790  1096.700   241.800  1096.300   243.700  1096.300   245.800  1096.000   248.500
GR  1095.900   249.400  1096.000   252.100  1095.700   255.000  1095.700   257.500  1095.800   262.800
GR  1096.100   266.600  1096.300   267.700  1096.300   268.200  1096.100   270.100  1096.300   273.400
GR  1096.400   275.800  1097.100   278.820  1097.400   279.800  1099.100   281.500  1099.300   282.900
GR  1103.300   288.500  1105.400   293.000  1108.700   295.000  1116.600   304.500  1117.900   307.400

NH     6.000      .040    21.700      .030    94.300      .040   183.000      .125   239.300      .030
NH   256.200      .125   286.000      .000      .000      .000      .000      .000      .000      .000
X1    15.000    49.000    21.700    94.300   390.000   370.000   390.000      .000      .000      .000
GR  1110.800      .000  1110.800     1.000  1108.600     6.300  1108.400     9.700  1100.900    18.100
GR  1098.200    21.700  1097.800    21.800  1097.100    23.300  1096.800    29.300  1096.700    33.800
GR  1095.200    40.800  1095.600    48.600  1096.700    53.800  1096.100    61.800  1096.100    66.300
GR  1096.000    67.800  1096.100    69.050  1096.200    72.600  1096.400    75.300  1096.300    76.300
GR  1096.500    77.800  1096.400    79.300  1097.000    84.300  1097.100    91.300  1097.800    94.300
GR  1099.000    98.400  1101.300   104.000  1101.100   141.600  1101.400   170.900  1100.600   176.900
GR  1100.400   183.000  1100.100   193.200  1100.300   198.000  1100.200   201.300  1099.500   210.000
GR  1099.800   222.200  1099.400   229.000  1099.800   234.200  1099.500   239.300  1097.800   242.500
GR  1097.500   243.530  1097.200   245.400  1097.000   249.800  1096.700   251.800  1097.500   256.200
GR  1099.300   260.000  1101.000   264.600  1115.000   285.960  1114.800   286.000      .000      .000

NH     3.000      .050    11.100      .030   110.800      .040   418.500      .000      .000      .000
X1    16.000    42.000    11.100   110.800   465.000   520.000   465.000      .000      .000      .000
GR  1112.700      .000  1112.600      .900  1111.600     1.000  1104.000    11.100  1100.900    14.920
GR  1100.200    17.420  1099.900    22.500  1099.800    25.500  1099.800    28.000  1099.700    30.500
GR  1099.800    31.600  1099.700    34.600  1099.800    40.100  1099.800    43.200  1099.700    46.700
GR  1099.600    49.700  1099.500    55.300  1099.500    60.900  1099.400    63.400  1099.500    67.900
GR  1099.600    75.000  1099.700    77.000  1099.600    80.000  1099.500    81.100  1099.700    83.100
GR  1099.800    89.600  1099.700    94.200  1099.800    95.200  1099.800    97.700  1100.200   103.800
GR  1100.200   105.800  1101.000   110.800  1101.500   138.900  1103.200   149.500  1103.800   157.600
GR  1104.400   208.800  1105.100   265.600  1106.300   331.300  1107.600   342.700  1111.600   359.900
GR  1112.600   367.110  1114.600   418.500      .000      .000      .000      .000      .000      .000

NH     3.000      .050    28.600      .030   172.520      .040   582.400      .000      .000      .000
X1    17.000    51.000    28.600   172.520   680.000   620.000   650.000      .000      .000      .000
GR  1124.100      .000  1123.800      .800  1104.200    23.400  1104.000    23.700  1100.800    28.600
GR  1100.400    29.520  1099.600    32.500  1099.600    34.700  1099.300    39.200  1099.300    45.900
GR  1099.100    48.100  1099.500    57.500  1099.700    66.500  1099.800    72.300  1099.600    79.000
GR  1099.600    82.100  1099.700    84.800  1099.700    87.000  1099.700    92.800  1099.300   100.900
GR  1099.300   108.500  1099.600   111.200  1099.500   113.000  1099.600   121.000  1099.500   124.100
GR  1099.400   128.200  1099.400   135.300  1099.600   137.100  1099.500   138.400  1099.400   145.100
1
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GR  1099.500   146.500  1099.600   150.100  1099.500   151.400  1099.600   158.100  1099.400   160.300
GR  1099.700   167.500  1100.400   172.520  1101.000   178.900  1104.300   190.000  1104.300   220.500
GR  1104.500   252.100  1105.400   279.400  1106.400   293.200  1108.000   303.100  1108.700   314.000
GR  1108.800   368.100  1109.600   424.900  1110.800   486.800  1111.200   520.400  1112.100   554.900
GR  1115.400   582.400      .000      .000      .000      .000      .000      .000      .000      .000

NH     5.000      .050   257.400      .030   323.510      .040   327.400      .125   335.410      .040
NH   417.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1    18.000    36.000   257.400   323.510   570.000   470.000   510.000      .000      .000      .000
GR  1120.600      .000  1119.200    10.100  1117.600    17.700  1110.700    39.200  1108.200    60.800
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GR   1106.400    93.700  1105.000   132.700  1104.400   151.300  1103.700   172.000  1103.100   181.300
GR   1101.700   186.400  1101.900   225.400  1101.200   257.400  1099.400   259.900  1099.500   274.500
GR   1099.500   276.500  1099.100   278.100  1099.000   283.000  1098.600   293.100  1098.600   296.800
GR   1099.000   300.800  1099.000   302.500  1098.800   304.100  1099.300   308.900  1099.200   310.900
GR   1099.500   314.600  1100.300   319.500  1100.400   321.500  1101.200   323.510  1104.200   326.800
GR   1104.600   327.400  1110.200   333.100  1111.300   333.700  1111.600   335.410  1112.100   376.300
GR   1113.500   417.000      .000      .000      .000      .000      .000      .000      .000      .000

NH      4.000      .050   241.070      .030   332.700      .040   336.400      .125   379.380      .000
X1     19.000    41.000   241.070   332.700   490.000   520.000   510.000      .000      .000      .000
GR   1115.900      .000  1114.000    17.600  1112.000    46.900  1109.600    87.200  1107.700   123.400
GR   1106.600   154.100  1106.400   183.500  1105.100   208.000  1103.700   220.600  1102.800   223.800
GR   1102.200   241.070  1101.500   245.100  1101.300   248.500  1101.200   253.800  1101.300   259.000
GR   1100.900   270.100  1100.700   276.400  1100.600   279.700  1100.500   285.500  1100.300   291.300
GR   1100.400   297.000  1100.600   298.000  1100.200   299.900  1100.100   304.700  1100.400   307.600
GR   1100.300   308.600  1100.100   310.500  1100.500   315.300  1100.500   318.200  1101.500   330.300
GR   1102.200   332.700  1103.100   335.300  1105.500   336.400  1107.800   338.100  1108.600   339.100
GR   1111.100   341.600  1112.500   342.800  1112.800   343.900  1115.100   344.400  1118.200   348.000
GR   1133.100   379.380      .000      .000      .000      .000      .000      .000      .000      .000

NH      4.000      .040   277.150      .030   364.320      .040   367.300      .125   400.190      .000
X1     20.000    39.000   277.150   364.320   360.000   450.000   440.000      .000      .000      .000
X2   1940.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
GR   1113.800      .000  1110.700    50.300  1110.000    91.000  1109.900   113.900  1109.000   123.000
GR   1107.000   133.700  1106.600   153.600  1105.600   175.500  1106.200   197.800  1105.900   226.200
GR   1105.400   244.400  1103.400   260.500  1102.200   277.150  1101.600   282.200  1101.600   285.500
GR   1101.300   289.300  1101.100   290.900  1101.200   293.800  1101.000   300.000  1100.800   305.000
GR   1101.100   307.900  1100.500   318.700  1100.600   321.600  1100.200   326.600  1100.200   330.300
GR   1100.100   331.200  1100.200   332.000  1100.100   334.100  1100.200   339.100  1100.900   344.500
GR   1100.700   351.500  1100.800   353.200  1100.900   357.700  1101.500   362.300  1102.300   364.320
GR   1105.800   367.300  1116.400   377.800  1127.300   389.000  1133.500   400.190      .000      .000

NH      4.000      .050   245.200      .030   347.300      .040   350.800      .125   361.300      .000
X1     21.000    43.000   245.200   347.300   390.000   460.000   430.000      .000      .000      .000
GR   1114.500      .000  1113.000    46.200  1112.000    52.500  1107.800    65.400  1107.300    96.000
GR   1106.200   109.600  1107.000   138.300  1107.500   171.900  1107.600   199.300  1107.400   218.800
GR   1106.400   236.800  1105.300   242.900  1104.700   245.200  1103.700   250.900  1103.100   252.400
GR   1102.900   254.900  1102.600   261.800  1102.400   269.700  1102.300   280.600  1102.300   286.500
GR   1102.400   296.900  1102.200   302.300  1102.300   303.800  1102.200   305.300  1102.300   306.700
GR   1102.400   309.200  1102.300   313.200  1102.300   316.600  1102.400   325.000  1102.300   328.500
GR   1102.400   330.500  1102.300   332.400  1102.600   333.900  1102.500   335.400  1102.800   340.800
GR   1102.900   343.800  1102.800   345.300  1103.600   347.300  1106.800   350.200  1107.100   350.800
GR   1109.500   352.000  1115.600   360.200  1115.800   361.300      .000      .000      .000      .000
1
  11-27-90      12:49:48                                                                    PAGE    7


NH      5.000      .050   165.700      .030   287.300      .040   291.600      .125   302.200      .040
NH    361.600      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1     22.000    40.000   165.700   287.300   375.000   430.000   410.000      .000      .000      .000
GR   1115.700      .000  1114.700    37.000  1113.400    50.300  1108.800    62.800  1107.900    81.800
GR   1107.600   100.600  1106.900   123.100  1105.900   133.000  1104.800   141.300  1104.300   165.700
GR   1103.700   167.700  1103.500   170.400  1103.700   174.200  1103.600   176.800  1103.300   192.400
GR   1103.200   210.200  1103.200   216.700  1103.300   220.400  1103.500   232.800  1103.300   236.600
GR   1103.200   251.100  1103.200   252.700  1103.300   255.900  1103.200   262.400  1103.100   264.000
GR   1103.300   271.000  1103.100   276.900  1103.500   280.100  1103.500   282.300  1104.400   287.300
GR   1104.800   288.300  1106.400   289.600  1107.100   291.400  1107.100   291.600  1113.900   301.100
GR   1114.000   302.000  1114.000   302.200  1114.900   327.000  1115.900   343.600  1116.500   361.600

NH      3.000      .050    20.000      .030   145.100      .040   351.800      .000      .000      .000
X1     23.000    48.000    20.000   145.100   405.000   415.000   410.000      .000      .000      .000
GR   1118.000      .000  1118.000     1.500  1115.500     6.900  1111.500     9.100  1111.600    12.800
GR   1107.700    17.900  1105.400    20.000  1104.900    20.900  1104.800    25.200  1104.700    29.100
GR   1104.600    32.700  1104.700    34.500  1104.500    36.300  1104.400    38.400  1104.600    41.600
GR   1104.800    47.300  1104.900    48.800  1105.400    50.800  1105.800    62.700  1105.200    79.900
GR   1104.600    81.400  1104.200    86.900  1103.700    92.300  1103.700    93.800  1103.500    98.800
GR   1103.600   102.300  1103.600   103.700  1103.500   110.700  1103.700   112.700  1103.600   114.200
GR   1103.500   118.700  1103.400   123.100  1103.600   125.100  1103.600   127.100  1104.100   138.500
GR   1104.600   143.000  1105.100   145.100  1106.000   146.600  1107.900   148.900  1108.400   168.600
GR   1109.300   187.600  1109.200   223.700  1109.400   265.200  1109.000   300.000  1108.800   326.100
GR   1110.300   334.400  1115.400   345.500  1117.100   351.800      .000      .000      .000      .000

NH      4.000      .125    16.500      .030   129.200      .060   175.400      .040   442.100      .000
X1     24.000    38.000    16.500   129.200   375.000   385.000   380.000      .000      .000      .000
GR   1125.600      .000  1124.700     2.100  1118.700     6.500  1108.500    16.500  1106.200    18.200
GR   1105.400    20.200  1105.400    24.700  1105.100    29.100  1104.600    36.400  1104.800    45.900
GR   1104.800    48.700  1104.900    52.600  1104.900    62.600  1104.900    71.500  1105.000    87.200
GR   1105.300   102.200  1105.400   110.000  1105.300   117.300  1105.400   121.800  1105.700   126.200
GR   1106.100   129.200  1106.500   137.000  1107.700   140.200  1106.500   146.400  1108.400   153.300
GR   1108.600   155.400  1109.000   175.400  1109.900   183.800  1110.300   220.300  1110.000   272.200
GR   1110.500   323.900  1111.000   327.100  1112.600   330.800  1115.600   338.600  1115.700   349.000
GR   1115.500   353.500  1117.200   397.300  1118.400   442.100      .000      .000      .000      .000

NH      7.000      .050    13.500      .125    66.800      .030   103.600      .050   128.000      .030
NH    223.900      .040   238.000      .060   328.900      .000      .000      .000      .000      .000
X1     25.000    53.000   128.000   223.900   575.000   550.000   575.000      .000      .000      .000
GR   1128.800      .000  1128.700     1.600  1120.300    13.500  1112.100    28.000  1110.400    57.400
GR   1109.200    66.000  1108.800    66.800  1106.700    71.200  1106.200    74.200  1106.400    93.400
GR   1106.100    99.400  1106.800   103.600  1108.700   108.700  1108.900   117.200  1107.700   122.100
GR   1106.800   128.000  1106.100   131.000  1105.900   132.700  1105.900   134.100  1106.100   135.800
GR   1106.000   136.800  1105.900   140.500  1106.000   142.300  1106.000   144.600  1105.800   147.000
GR   1105.700   150.400  1105.500   152.800  1105.600   155.200  1105.700   157.300  1105.600   160.000
GR   1105.700   163.700  1105.600   165.100  1105.700   168.900  1105.600   170.600  1105.700   172.300
GR   1105.700   174.600  1105.700   177.400  1105.700   180.800  1105.600   185.600  1105.700   187.300
GR   1105.600   190.000  1105.500   199.500  1105.600   208.400  1106.000   216.300  1106.100   221.400
GR   1106.700   223.900  1109.100   226.200  1113.800   232.000  1115.300   234.200  1115.500   237.100
GR   1115.600   238.000  1116.400   291.900  1117.800   328.900      .000      .000      .000      .000
1
  11-27-90      12:49:48                                                                    PAGE    8


NH      5.000      .100    89.200      .030   129.700      .100   234.900      .030   305.000      .040
NH    322.100      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1     26.000    45.000   234.900   305.000   305.000   280.000   295.000      .000      .000      .000
GR   1129.700      .000  1129.300     1.300  1117.200    18.800  1110.500    40.200  1109.900    50.300
GR   1109.100    83.600  1108.500    86.300  1108.000    89.200  1108.000   101.100  1107.700   119.100
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GR  1107.900   129.700  1109.100   131.200  1109.500   163.200  1109.700   181.500  1108.800   187.500
GR  1109.200   197.800  1108.600   203.800  1108.500   215.300  1109.800   222.500  1109.900   225.700
GR  1109.500   231.400  1107.400   234.900  1107.100   236.500  1106.400   238.000  1106.500   239.700
GR  1106.100   244.800  1106.000   249.400  1105.800   253.200  1105.400   256.100  1105.800   259.900
GR  1105.700   262.500  1105.800   270.100  1105.700   275.600  1105.800   286.100  1105.600   289.500
GR  1105.600   291.600  1105.500   292.900  1105.600   295.000  1106.300   303.000  1107.000   305.000
GR  1108.100   307.500  1109.400   308.700  1109.700   308.900  1120.100   320.200  1120.100   322.100

NH     6.000      .050    50.200      .030    72.700      .050   181.300      .030   288.800      .100
NH   349.100      .040   359.100      .000      .000      .000      .000      .000      .000      .000
X1    27.000    48.000   181.300   288.800   360.000   390.000   385.000      .000      .000      .000
GR  1134.200      .000  1125.800    13.700  1122.100    25.600  1118.000    35.600  1110.600    47.900
GR  1110.600    48.000  1108.700    50.200  1108.500    51.100  1107.900    52.000  1107.800    54.800
GR  1107.700    58.100  1107.700    60.900  1107.500    65.100  1107.600    68.400  1107.800    71.700
GR  1108.500    72.700  1109.000    77.300  1109.400   114.300  1109.500   138.200  1108.300   178.300
GR  1108.100   181.300  1107.700   215.800  1107.000   219.700  1106.900   221.900  1106.900   225.800
GR  1106.800   233.600  1106.500   236.300  1106.700   238.000  1106.600   244.100  1106.700   250.800
GR  1106.800   254.600  1106.600   257.400  1106.600   259.600  1106.600   262.400  1106.800   270.200
GR  1106.700   272.900  1106.700   276.600  1106.900   279.000  1107.000   280.700  1107.700   283.700
GR  1109.200   285.700  1111.700   287.400  1111.700   288.800  1111.900   331.900  1111.900   336.500
GR  1115.200   343.000  1118.600   349.100  1122.500   359.100      .000      .000      .000      .000

NH     4.000      .050    23.600      .100    61.700      .030   141.600      .040   531.300      .000
X1    28.000    33.000    61.700   141.600   640.000   540.000   585.000      .000      .000      .000
GR  1136.200      .000  1136.200     1.800  1126.600    23.600  1113.300    45.800  1112.300    52.600
GR  1113.300    61.700  1111.600    62.400  1109.200    64.500  1108.700    65.720  1108.200    67.700
GR  1107.900    71.900  1107.700    75.300  1107.300    79.500  1107.400    82.000  1107.500    87.900
GR  1107.800    93.000  1107.900   109.100  1107.900   118.300  1107.900   132.700  1108.200   138.600
GR  1108.800   141.600  1109.400   146.400  1111.800   153.600  1111.900   153.700  1112.400   162.300
GR  1112.900   171.600  1113.700   231.900  1114.600   311.800  1118.900   333.200  1119.700   404.200
GR  1120.700   480.800  1123.000   505.800  1126.500   531.300      .000      .000      .000      .000

NH     5.000      .050   165.300      .030   332.700      .040   339.600      .125   342.800      .040
NH   624.900      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1    29.000    43.000   165.300   332.700   500.000   275.000   410.000      .000      .000      .000
GR  1133.900      .000  1124.700    23.400  1120.300    69.000  1116.100   110.900  1116.000   111.700
GR  1113.300   119.000  1112.200   120.500  1111.400   135.400  1110.400   144.500  1110.400   146.300
GR  1111.500   147.300  1111.800   163.400  1110.400   165.300  1110.100   165.600  1109.200   167.600
GR  1109.200   173.200  1109.100   186.600  1109.200   198.900  1109.000   210.100  1109.300   225.700
GR  1109.000   241.400  1109.200   251.500  1109.400   266.000  1109.200   270.500  1109.000   276.000
GR  1109.200   280.500  1109.000   288.300  1109.000   295.000  1108.900   301.800  1109.500   318.600
GR  1110.000   322.600  1110.000   326.200  1110.000   328.500  1109.600   332.700  1109.800   336.800
GR  1112.000   339.600  1112.900   340.000  1116.300   342.800  1119.600   351.900  1119.800   477.400
GR  1118.300   522.300  1121.100   594.200  1126.200   624.900      .000      .000      .000      .000
1
 11-27-90      12:49:48                                                                   PAGE    9


NH     6.000      .040   136.600      .030   169.900      .100   252.600      .030   376.500      .040
NH   394.100      .125   409.400      .000      .000      .000      .000      .000      .000      .000
X1    30.000    54.000   252.600   376.500   500.000   350.000   415.000      .000      .000      .000
X2  1934.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
GR  1125.900      .000  1123.200    13.400  1121.100    16.800  1120.800    24.000  1119.800    26.800
GR  1116.300    38.800  1116.900    43.100  1116.800    50.300  1114.300    67.600  1114.100   102.500
GR  1114.600   133.900  1114.200   136.600  1111.700   143.100  1111.400   143.100  1111.100   145.100
GR  1110.500   148.100  1110.400   159.100  1110.400   162.800  1110.800   166.500  1111.200   168.900
GR  1111.500   169.900  1112.200   173.300  1111.700   179.800  1111.900   191.800  1111.900   220.900
GR  1112.300   252.600  1111.100   258.200  1110.400   260.200  1110.100   273.200  1109.900   282.400
GR  1109.900   291.500  1110.000   293.800  1110.000   296.900  1109.800   299.900  1110.100   307.600
GR  1110.100   309.900  1110.200   312.200  1110.300   321.300  1110.200   324.400  1110.300   327.400
GR  1110.200   332.000  1110.400   341.200  1110.400   348.800  1110.300   351.100  1110.200   354.200
GR  1110.300   363.300  1110.300   367.200  1110.400   372.500  1111.300   376.500  1112.200   385.200
GR  1114.100   387.600  1119.500   394.100  1125.200   403.300  1127.000   409.400      .000      .000

NH     3.000      .050   413.900      .030   494.800      .100   529.100      .000      .000      .000
X1    31.000    54.000   413.900   494.800   390.000   345.000   350.000      .000      .000      .000
GR  1122.700      .000  1122.600     9.800  1122.000    31.000  1119.600    64.000  1119.800    68.700
GR  1119.200    75.100  1118.100    91.200  1118.100   126.800  1116.800   146.000  1117.300   178.800
GR  1118.600   188.100  1119.700   206.200  1117.200   215.700  1117.200   221.200  1117.800   224.100
GR  1117.800   229.800  1116.100   247.900  1115.200   270.000  1115.400   322.900  1115.200   347.800
GR  1115.500   350.900  1116.300   351.400  1116.400   353.200  1114.500   357.800  1113.400   362.600
GR  1114.200   373.200  1113.900   408.900  1111.900   413.900  1111.400   428.400  1111.000   432.400
GR  1109.900   436.300  1109.700   441.600  1109.500   445.400  1109.300   448.800  1109.000   451.200
GR  1108.700   454.600  1108.500   459.000  1107.600   462.800  1107.300   466.700  1108.500   471.200
GR  1108.400   474.900  1108.500   476.400  1108.700   482.100  1108.900   483.600  1109.100   486.000
GR  1109.500   488.900  1109.500   491.800  1111.500   494.800  1112.100   494.900  1114.800   499.700
GR  1125.000   513.700  1134.700   526.800  1136.100   527.400  1136.000   529.100      .000      .000

NH     4.000      .040   349.200      .030   472.400      .040   608.200      .125   662.000      .000
X1    32.000    50.000   349.200   472.400   525.000   700.000   625.000      .000      .000      .000
GR  1122.100      .000  1122.600    35.400  1121.700    42.600  1122.600    65.200  1123.500   113.600
GR  1121.000   160.800  1120.100   175.000  1119.600   218.600  1120.100   267.100  1119.800   303.700
GR  1120.400   319.500  1117.600   329.300  1117.300   338.400  1116.000   342.900  1115.300   344.100
GR  1115.000   346.800  1113.800   349.200  1113.000   352.700  1112.000   354.700  1111.900   365.300
GR  1112.100   367.000  1111.700   375.300  1111.900   377.000  1111.600   387.600  1111.800   389.400
GR  1111.700   396.400  1112.000   407.600  1112.100   421.100  1112.100   431.700  1112.200   444.700
GR  1112.000   451.100  1112.200   453.500  1112.000   458.200  1112.200   460.500  1112.300   464.100
GR  1112.300   467.300  1112.900   469.100  1113.200   472.400  1113.600   477.800  1114.600   479.500
GR  1115.300   482.100  1116.100   484.200  1116.200   484.600  1116.500   486.600  1116.900   520.200
GR  1117.000   557.200  1116.800   608.200  1117.900   637.200  1124.100   650.000  1130.000   662.000

NH     4.000      .040   107.700      .030   215.100      .040   401.800      .125   458.000      .000
X1    33.000    44.000   107.700   215.100   315.000   305.000   310.000      .000      .000      .000
GR  1124.800      .000  1122.100    33.100  1123.400    66.200  1122.200    96.600  1122.000    97.600
GR  1116.500   105.700  1114.400   107.700  1113.400   111.200  1112.800   113.200  1112.400   123.100
GR  1112.700   131.800  1112.600   135.300  1112.500   139.400  1112.700   144.600  1112.500   150.400
GR  1112.700   154.500  1112.500   158.600  1112.600   161.500  1112.300   171.400  1112.400   178.400
GR  1112.200   183.000  1112.200   185.400  1112.000   191.800  1111.900   196.400  1112.100   197.600
GR  1112.000   199.300  1112.300   202.200  1112.100   205.200  1112.600   212.100  1113.400   215.100
GR  1114.000   220.700  1115.200   223.100  1115.600   228.500  1116.500   232.200  1117.000   266.700
GR  1117.300   307.300  1117.500   339.800  1118.500   382.000  1118.800   389.400  1120.800   397.300
1
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GR  1121.900   401.800  1122.200   416.500  1125.500   444.600  1127.100   458.000      .000      .000
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NH     3.000      .040    85.800      .030   152.000      .040   464.000      .000      .000      .000
X1    34.000    45.000    85.800   152.000   390.000   390.000   390.000      .000      .000      .000
GR  1126.600      .000  1126.300    22.600  1126.100    29.400  1125.700    33.400  1122.500    41.000
GR  1121.900    66.900  1121.600    74.600  1119.100    79.300  1119.100    80.900  1117.100    85.500
GR  1115.100    85.600  1114.800    85.800  1114.000    87.500  1113.200    88.500  1113.100    90.900
GR  1112.700    94.900  1112.000    98.800  1112.200   101.600  1112.300   104.400  1112.200   106.000
GR  1112.100   109.200  1112.300   112.800  1112.300   114.800  1112.500   119.100  1112.400   120.300
GR  1112.600   125.900  1112.800   127.500  1112.800   132.300  1112.900   133.900  1113.000   142.600
GR  1113.400   149.000  1114.000   152.000  1115.300   166.700  1115.500   189.400  1114.600   204.300
GR  1114.400   230.900  1116.300   242.800  1116.900   244.500  1118.400   249.900  1118.800   278.800
GR  1119.800   325.100  1121.300   372.700  1123.800   392.300  1127.200   437.000  1129.800   464.000

NH     3.000      .040   137.000      .030   264.800      .040   364.400      .000      .000      .000
X1    35.000    46.000   137.000   264.800   295.000   295.000   295.000      .000      .000      .000
GR  1126.300      .000  1126.000    36.800  1124.800    57.500  1124.700    59.600  1124.200    61.000
GR  1122.400    76.000  1119.000    89.500  1118.600   110.300  1118.000   128.700  1114.900   137.000
GR  1114.200   141.000  1114.000   147.500  1114.100   149.800  1113.900   151.200  1113.700   157.700
GR  1113.700   160.500  1113.600   164.200  1113.400   175.400  1113.700   180.500  1114.100   185.600
GR  1114.400   193.000  1114.900   198.000  1115.200   204.400  1115.100   209.100  1114.500   214.100
GR  1114.700   215.200  1114.300   217.200  1114.300   222.100  1114.300   225.800  1114.300   231.400
GR  1114.200   242.500  1114.300   245.000  1114.600   256.700  1114.500   259.800  1115.100   264.800
GR  1115.700   267.900  1115.400   274.400  1116.200   279.200  1117.900   286.700  1120.900   300.500
GR  1121.300   302.000  1123.200   331.900  1124.300   345.200  1124.300   349.400  1125.000   353.900
GR  1126.000   364.400      .000      .000      .000      .000      .000      .000      .000      .000

NC      .000      .000      .000      .300      .500      .000      .000      .000      .000      .000
NH     3.000      .040   217.800      .030   366.500      .050   450.900      .000      .000      .000
X1    36.000    59.000   217.800   366.500    50.000    50.000    50.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1120.200  1121.400      .000
GR  1126.900      .000  1126.300    48.100  1125.900    83.100  1124.500   105.000  1123.600   117.200
GR  1122.800   122.200  1122.400   128.500  1122.300   138.800  1121.300   158.100  1119.900   191.700
GR  1119.800   203.400  1119.500   210.700  1118.900   214.700  1119.500   216.500  1119.700   217.800
GR  1118.100   217.800  1116.400   217.800  1116.000   220.000  1115.300   220.500  1114.600   224.500
GR  1114.300   226.100  1113.900   229.800  1114.100   231.900  1114.100   233.000  1114.200   234.600
GR  1114.200   238.900  1114.100   243.100  1114.300   249.500  1114.500   255.300  1114.300   259.600
GR  1114.400   261.200  1114.400   262.800  1114.400   264.900  1114.500   268.100  1114.500   276.100
GR  1114.700   281.900  1114.600   286.200  1114.700   288.300  1114.600   292.300  1114.600   294.000
GR  1114.700   300.600  1114.700   309.000  1114.500   319.000  1115.200   329.000  1114.500   332.400
GR  1114.400   334.900  1114.700   347.400  1115.300   351.400  1115.900   353.900  1116.700   360.800
GR  1117.500   364.000  1118.500   366.000  1121.000   366.500  1121.000   366.700  1121.900   373.900
GR  1123.200   392.900  1124.600   412.000  1125.900   427.800  1127.300   450.900      .000      .000

NH     3.000      .015   100.000      .028   245.400      .015   305.000      .000      .000      .000
X1    37.100    34.000   100.000   245.400     1.000     1.000     1.000      .000      .000      .000
BT     3.000   100.000  1120.400  1119.300   173.000  1121.300  1120.200   245.400  1121.600  1120.500
GR  1123.800      .000  1122.100    20.000  1121.100    40.000  1120.400    60.000  1120.000    80.000
GR  1120.300   100.000  1116.000   100.000  1115.300   100.500  1114.600   106.000  1114.100   123.000
GR  1114.500   135.500  1114.300   139.500  1114.500   148.000  1114.500   156.000  1114.700   162.000
GR  1114.600   173.000  1120.200   173.000  1120.200   175.000  1114.600   175.000  1114.700   180.000
GR  1114.700   189.000  1114.500   199.000  1115.200   209.000  1114.500   212.500  1114.400   217.000
GR  1114.700   227.500  1115.300   231.500  1115.900   234.000  1116.700   241.000  1117.500   244.000
GR  1120.500   245.400  1122.300   265.000  1123.400   285.000  1124.600   305.000      .000      .000
1
 11-27-90      12:49:48                                                                  PAGE    11


NH     3.000      .015   100.000      .028   245.400      .015   305.000      .000      .000      .000
X1    37.200      .000      .000      .000     8.000     8.000     8.000      .000      .000      .000
BT     3.000   100.000  1120.400  1119.300   173.000  1121.300  1120.200   245.400  1121.600  1120.500

NH     3.000      .040   177.600      .030   323.500      .040   405.300      .000      .000      .000
X1    38.000    61.000   177.600   323.500     1.000     1.000     1.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000    20.200    21.400      .000
GR  1126.300      .000  1125.500    46.400  1123.700    70.000  1122.800    89.900  1122.100   102.300
GR  1121.900   104.300  1121.900   107.900  1121.900   110.300  1121.400   113.700  1121.400   119.200
GR  1120.600   122.800  1120.300   128.100  1120.100   162.900  1119.900   167.300  1119.700   170.900
GR  1119.900   173.800  1119.900   176.400  1120.100   177.600  1118.300   177.600  1115.400   178.400
GR  1114.600   178.400  1114.600   181.400  1114.200   187.000  1114.200   189.500  1114.300   192.000
GR  1114.200   199.400  1114.400   204.400  1114.300   211.200  1114.400   214.300  1114.500   221.800
GR  1114.600   225.500  1114.600   229.800  1114.700   236.700  1114.600   245.400  1114.700   252.800
GR  1114.700   262.100  1115.000   269.600  1114.800   274.600  1114.800   277.000  1114.500   283.900
GR  1114.700   290.100  1114.500   292.600  1114.600   294.400  1114.600   300.600  1114.400   308.800
GR  1115.300   312.800  1117.100   321.400  1120.000   321.600  1120.000   322.500  1118.500   323.200
GR  1120.600   323.500  1121.200   323.900  1121.200   328.500  1121.800   331.200  1122.000   338.100
GR  1123.400   369.700  1125.300   383.900  1125.700   384.700  1126.500   392.600  1126.400   394.500
GR  1126.800   405.300      .000      .000      .000      .000      .000      .000      .000      .000

NH     5.000      .040   141.500      .100   191.200      .040   284.700      .030   422.000      .050
NH   477.800      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1    39.000    63.000   284.700   422.000    40.000    40.000    40.000      .000      .000      .000
GR  1126.800      .000  1126.300    45.800  1125.600   104.600  1124.100   141.500  1122.700   181.600
GR  1122.400   191.200  1122.000   210.500  1121.400   233.800  1120.100   238.400  1118.900   247.200
GR  1118.700   255.100  1118.400   260.500  1117.500   275.100  1116.500   280.600  1115.900   284.700
GR  1115.300   287.100  1114.600   288.600  1114.200   291.700  1114.400   298.600  1114.400   312.200
GR  1114.600   313.400  1114.400   315.300  1114.400   318.400  1114.400   319.600  1114.600   322.700
GR  1114.200   325.200  1114.400   327.000  1114.600   329.300  1114.400   330.800  1114.600   332.700
GR  1114.600   339.500  1114.600   345.700  1114.800   353.100  1114.800   363.100  1114.600   369.300
GR  1114.600   370.500  1114.600   372.400  1114.600   374.500  1114.600   375.500  1114.600   377.900
GR  1114.400   380.100  1114.400   384.100  1114.600   385.400  1114.400   388.500  1114.400   393.500
GR  1114.600   395.300  1114.400   401.500  1114.600   406.500  1114.400   408.600  1114.400   410.800
GR  1114.600   413.000  1114.600   414.200  1114.600   418.000  1115.400   422.000  1116.200   426.000
GR  1118.500   430.700  1118.600   432.200  1121.800   439.700  1122.200   441.500  1123.700   443.500
GR  1123.900   444.100  1125.900   472.200  1126.200   477.800      .000      .000      .000      .000

NC      .000      .000      .000      .100      .300      .000      .000      .000      .000      .000
NH     4.000      .040   580.400      .030   667.700      .040   671.600      .125   681.900      .000
X1    40.000    42.000   580.400   667.700   325.000   335.000   330.000      .000      .000      .000
GR  1127.600      .000  1127.100    67.800  1125.600   124.200  1124.600   187.100  1124.800   233.800
GR  1124.600   256.200  1123.600   278.300  1123.200   343.800  1122.000   371.700  1120.900   403.600
GR  1120.100   451.900  1119.000   507.200  1118.400   531.400  1117.300   549.300  1116.900   550.900
GR  1115.900   580.400  1115.300   582.400  1115.300   584.500  1115.100   587.500  1114.800   605.300
GR  1114.500   611.400  1114.500   621.300  1114.700   622.400  1114.700   623.200  1114.500   625.000
GR  1114.700   626.600  1114.400   629.800  1114.400   634.900  1114.200   638.300  1114.600   646.800
GR  1114.700   652.700  1114.700   656.200  1114.700   657.500  1114.700   659.100  1114.800   662.800
GR  1114.800   664.700  1115.900   667.700  1116.200   669.000  1118.800   671.600  1122.900   675.700
GR  1124.300   677.600  1127.300   681.900      .000      .000      .000      .000      .000      .000
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NH     4.000      .040   434.200      .030   555.700      .040   560.900      .125   573.600      .000
X1    41.000    49.000   434.200   555.700   385.000   450.000   415.000      .000      .000      .000
GR  1124.800      .000  1124.900    10.600  1124.000    38.600  1123.500    55.400  1123.900   107.800
GR  1122.400   138.500  1121.500   207.100  1120.800   280.500  1120.300   349.700  1119.900   371.100
GR  1120.400   412.200  1120.000   423.600  1119.800   424.800  1118.000   427.200  1117.700   432.000
GR  1116.600   434.200  1115.400   456.500  1114.800   460.500  1114.700   464.700  1114.600   472.500
GR  1114.600   474.000  1114.600   488.000  1114.400   490.200  1114.500   494.200  1114.300   496.100
GR  1114.300   508.200  1114.200   510.000  1114.300   513.300  1114.300   521.000  1114.200   522.400
GR  1113.900   525.100  1114.200   528.100  1114.300   530.800  1114.200   533.700  1114.300   537.200
GR  1114.200   538.200  1114.300   544.500  1114.200   547.200  1114.400   550.700  1115.600   555.700
GR  1116.000   556.800  1117.100   556.800  1118.300   558.200  1119.900   559.800  1120.200   560.900
GR  1124.100   565.600  1125.000   566.700  1126.100   570.700  1128.200   573.600      .000      .000

NH     4.000      .040   380.400      .030   459.900      .040   498.800      .050   734.300      .000
X1    42.000    36.000   380.400   459.900   245.000   365.000   305.000      .000      .000      .000
GR  1126.000   154.600  1125.000   189.600  1124.000   277.600  1123.000   354.600  1122.400   369.600
GR  1122.300   371.300  1120.400   373.900  1117.900   376.200  1117.400   380.400  1117.000   380.500
GR  1116.100   383.000  1116.000   388.000  1115.500   395.300  1114.800   402.500  1115.100   411.300
GR  1115.500   422.300  1115.900   432.000  1116.200   442.700  1116.300   456.900  1117.100   459.900
GR  1118.000   470.400  1119.100   475.600  1119.600   497.200  1120.400   498.800  1120.400   517.300
GR  1120.900   523.800  1121.000   528.100  1121.100   568.800  1120.700   598.200  1120.800   605.500
GR  1121.700   654.100  1122.200   685.600  1123.100   693.100  1124.200   719.200  1127.700   728.700
GR  1129.800   734.300      .000      .000      .000      .000      .000      .000      .000      .000

NH     4.000      .040   167.900      .030   288.000      .100   320.800      .040   517.000      .000
X1    43.000    49.000   167.900   288.000   600.000   495.000   545.000      .000      .000      .000
GR  1138.000      .000  1133.100    18.400  1131.300    25.500  1130.800    33.700  1130.200    35.200
GR  1128.500    46.600  1124.400    65.900  1124.100    72.100  1123.800    80.700  1123.100    87.500
GR  1121.200    99.300  1120.300   134.800  1119.600   144.500  1119.500   167.900  1118.300   175.500
GR  1117.700   178.500  1117.400   186.000  1117.500   192.100  1117.100   204.400  1117.100   207.700
GR  1117.000   212.300  1117.000   223.900  1116.900   236.500  1117.100   248.200  1117.100   260.400
GR  1117.100   271.400  1117.300   283.000  1118.300   288.000  1119.100   297.600  1120.400   300.000
GR  1120.800   305.100  1121.700   306.000  1122.500   309.600  1122.700   320.800  1122.600   342.200
GR  1122.500   362.400  1122.600   382.800  1122.800   405.000  1122.900   415.700  1122.300   417.100
GR  1122.800   419.600  1122.700   425.100  1122.300   427.000  1122.700   428.600  1122.600   459.200
GR  1123.100   466.200  1127.000   477.400  1129.600   489.200  1130.700   517.000      .000      .000

NH     7.000      .040    70.300      .015    80.500      .040   261.900      .030   343.300      .040
NH   373.200      .015   380.600      .040   541.200      .000      .000      .000      .000      .000
X1    44.000    59.000   261.900   343.300   435.000   425.000   430.000      .000  1100.000      .000
X2  1913.000      .000      .000      .000      .000      .000      .000      .000      .000      .000
GR    27.400    70.300    27.500    74.800    27.400    80.500    27.400    80.900    24.300    91.100
GR    23.500    95.200    23.600   124.500    23.200   148.200    22.900   166.500    23.100   180.700
GR    22.700   198.700    22.500   199.400    22.400   199.700    20.800   208.800    19.800   212.500
GR    20.600   216.100    20.100   229.900    20.200   232.800    19.500   246.900    19.300   251.800
GR    19.000   252.700    19.300   255.000    19.400   257.400    19.400   261.900    19.100   263.300
GR    18.200   265.300    18.000   269.600    17.900   273.100    17.600   277.200    17.700   280.300
GR    17.600   281.500    17.700   284.600    17.300   287.300    17.200   291.800    17.400   293.600
GR    17.300   295.000    17.400   298.500    17.300   300.000    17.400   302.000    17.500   304.300
GR    17.400   306.500    17.600   311.000    17.600   313.700    17.700   316.600    17.300   321.300
GR    17.500   322.900    17.300   324.700    18.000   335.200    19.200   338.200    22.000   343.300
GR    25.000   348.600    27.000   349.100    27.500   350.900    27.300   373.200    27.200   380.600
GR    27.200   386.700    27.400   470.500    28.300   502.900    33.300   541.200      .000      .000
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NC      .000      .000      .000      .300      .500      .000      .000      .000      .000      .000
NH     6.000      .040   106.020      .015   164.970      .040   251.200      .030   402.700      .040
NH   461.430      .015   498.330      .000      .000      .000      .000      .000      .000      .000
X1    45.000    53.000   251.200   402.700   120.000    60.000    85.000      .900      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1127.000  1127.000      .000
GR  1131.200      .000  1130.400    18.200  1129.400    45.200  1129.000    83.600  1128.200   117.800
GR  1127.500   155.500  1127.300   183.300  1127.300   209.400  1127.900   241.100  1127.200   243.000
GR  1126.900   244.800  1124.900   251.200  1124.700   253.800  1123.500   257.300  1122.800   258.700
GR  1121.300   263.600  1120.700   266.000  1120.500   268.500  1120.100   304.200  1119.800   308.200
GR  1119.100   310.200  1119.400   318.700  1119.500   320.000  1119.400   320.800  1119.200   321.900
GR  1119.200   324.500  1119.200   325.900  1119.400   328.700  1119.300   332.400  1119.200   333.400
GR  1119.100   338.700  1117.400   344.200  1117.400   347.500  1117.300   352.000  1117.500   355.200
GR  1117.300   358.500  1117.300   360.500  1117.200   361.900  1117.100   363.200  1117.700   368.700
GR  1119.800   371.700  1120.000   386.500  1122.300   391.900  1124.100   396.100  1125.400   400.900
GR  1125.600   402.700  1127.600   408.100  1128.100   412.800  1128.400   436.700  1128.500   453.900
GR  1128.900   481.700  1129.700   512.700  1131.100   553.700      .000      .000      .000      .000

SB      .900     1.000     2.600      .000   100.000     3.000   740.000     3.000  1119.200  1119.200
NH     3.000      .015   198.000      .026   333.000      .015   478.800      .000      .000      .000
NH     6.000      .015    75.420      .040   236.250      .030   372.960      .040   405.900      .020
NH   424.170      .040   474.300      .000      .000      .000      .000      .000      .000      .000
X1    47.000    52.000   262.500   414.400    13.000    13.000    13.000      .900      .000      .000
X2      .000      .000     1.000  1125.600  1127.600      .000      .000     1.330      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1127.600  1127.600      .000
GR  1132.600      .000  1130.700    42.900  1129.300    83.800  1128.100   126.400  1127.500   164.900
GR  1127.300   196.100  1127.300   225.900  1125.400   253.100  1127.100   256.000  1125.000   262.500
GR  1124.700   265.200  1123.600   268.300  1122.900   269.900  1123.100   273.800  1120.200   278.900
GR  1119.900   319.000  1119.300   323.200  1118.500   325.700  1118.400   326.400  1117.900   329.400
GR  1117.900   330.500  1117.700   333.100  1117.600   336.800  1117.800   339.800  1117.800   340.900
GR  1117.700   342.000  1117.700   343.800  1117.800   346.800  1117.800   349.400  1117.700   352.700
GR  1117.700   356.000  1117.400   359.200  1116.700   365.900  1116.700   367.200  1116.600   369.800
GR  1117.000   375.700  1116.900   378.100  1117.400   385.900  1117.300   387.900  1118.100   391.400
GR  1119.300   392.400  1119.500   398.500  1122.400   403.400  1123.900   406.500  1124.700   408.400
GR  1125.700   414.400  1127.900   420.100  1128.100   423.900  1128.500   451.000  1129.000   471.300
GR  1129.800   515.200  1130.100   527.000      .000      .000      .000      .000      .000      .000

NH     5.000      .050   181.300      .035   207.500      .050   295.200      .030   367.600      .040
NH   533.900      .000      .000      .000      .000      .000      .000      .000      .000      .000
X1    48.000    44.000   295.200   367.600   125.000   165.000   145.000      .000  1100.000      .000
GR    39.200      .000    38.900     4.700    30.800    22.800    28.200    35.500    24.500    44.000
GR    24.200    51.000    24.100    91.000    24.100   173.700    23.200   177.900    20.100   181.300
GR    19.200   197.300    20.000   207.500    21.500   212.400    21.200   295.200    19.800   303.300
GR    19.400   306.000    18.600   307.500    17.900   312.200    17.500   318.400    17.300   319.400
GR    17.300   321.500    17.600   324.500    17.400   325.300    17.500   326.500    17.200   329.000
GR    17.400   333.500    17.300   340.000    17.800   349.400    18.500   355.900    19.400   358.900
GR    20.100   361.300    22.900   367.600    23.300   369.400    27.900   374.400    28.100   398.700
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GR     28.400    428.700     28.300    457.300     28.800    480.900     29.700    483.100     29.600    493.000
GR     28.700    497.500     28.600    502.600     28.700    503.500     29.700    533.900       .000       .000
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 11-27-90    12:49:48                                                                                  PAGE   14


NC       .000       .000       .000       .100       .300       .000       .000       .000       .000       .000
NH      3.000       .050    108.200       .030    240.900       .040    580.700       .000       .000       .000
X1     49.000     54.000    108.200    240.900    330.000    350.000    355.000       .000   1100.000       .000
GR     47.000       .000     46.600      8.000     41.800     19.300     37.000     30.600     33.500     42.300
GR     27.300     65.500     25.600     82.800     23.700     89.600     22.600     90.000     21.200     93.300
GR     21.100     95.700     21.600     98.100     21.100    108.200     20.400    110.900     19.700    112.900
GR     19.200    122.600     19.100    135.200     18.900    144.100     19.000    150.700     18.900    163.300
GR     19.100    169.200     19.100    183.300     19.200    190.700     20.400    193.700     20.800    196.400
GR     21.100    201.800     20.900    205.800     20.400    207.000     19.400    208.100     19.200    214.300
GR     19.100    221.900     19.200    226.300     19.000    232.100     19.700    237.900     20.400    239.900
GR     21.100    240.900     21.800    244.300     21.200    277.700     20.700    280.300     20.700    287.300
GR     23.300    292.400     24.000    318.200     23.800    319.300     25.000    330.700     25.300    358.900
GR     25.500    385.300     25.800    415.400     29.600    432.000     29.900    465.100     29.700    505.000
GR     30.200    535.000     32.100    570.700     31.800    576.900     32.700    580.700       .000       .000

NH      4.000       .040     10.100       .030     94.000       .100    132.500       .040    450.000       .000
X1     49.100     26.000     10.100     94.000    395.000    425.000    405.000       .000   1100.000       .000
GR     31.100       .000     28.300      3.000     22.700     10.100     21.500     12.800     20.600     14.800
GR     20.300     26.300     20.400     26.900     20.300     31.100     19.300     41.900     19.800     51.500
GR     20.200     66.000     20.200     75.000     20.300     80.400     21.000     90.700     21.500     94.000
GR     22.400    104.600     22.500    114.600     23.400    118.300     24.000    132.500     23.500    133.300
GR     24.700    147.500     24.000    215.000     24.000    220.000     25.000    230.000     26.000    430.000
GR     27.000    450.000       .000       .000       .000       .000       .000       .000       .000       .000

NH      5.000       .040     31.000       .030    144.100       .040    167.400       .060    252.300       .040
NH    592.300       .000       .000       .000       .000       .000       .000       .000       .000       .000
X1     50.000     42.000     31.000    144.100    400.000    225.000    335.000       .000   1100.000       .000
GR     41.600       .000     41.100      3.500     33.100     16.500     25.200     27.400     23.400     31.000
GR     22.400     36.000     22.300     38.000     22.400     39.000     22.500     40.500     22.400     43.400
GR     21.500     45.400     21.100     50.400     21.200     54.400     21.100     64.800     20.900     68.500
GR     21.000     73.000     20.800     81.100     20.900     86.100     21.200     96.100     21.200    109.200
GR     22.100    119.200     22.200    126.000     22.400    134.200     22.400    140.100     22.900    144.100
GR     22.800    151.300     22.500    153.600     22.800    157.300     23.700    167.400     24.200    179.800
GR     23.900    214.100     23.400    227.700     23.000    228.600     22.900    233.800     23.500    234.700
GR     23.400    245.200     25.300    250.800     25.600    251.300     25.600    252.300     26.000    477.300
GR     27.000    522.300     28.000    592.300       .000       .000       .000       .000       .000       .000

NH      4.000       .040    252.800       .030    350.300       .040    362.100       .125    387.800       .000
X1     51.000     39.000    252.800    350.300    440.000    555.000    505.000       .000       .000       .000
X2   1590.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR   1137.300       .000   1134.000     12.400   1128.400     29.700   1128.000     36.700   1127.800     38.900
GR   1127.000     74.400   1127.000    143.000   1126.200    203.200   1125.700    212.100   1125.300    231.900
GR   1124.900    234.900   1124.200    236.800   1123.700    252.800   1123.200    257.600   1122.200    259.600
GR   1122.300    266.000   1122.300    272.400   1122.000    275.900   1122.200    278.800   1122.300    283.300
GR   1122.300    288.700   1122.300    294.600   1122.100    297.600   1122.400    302.500   1122.400    308.900
GR   1122.400    314.800   1122.500    317.700   1122.600    320.200   1122.800    330.200   1123.000    334.900
GR   1122.800    341.800   1122.800    345.300   1123.200    350.300   1123.700    357.000   1124.400    362.100
GR   1126.200    363.200   1131.700    370.400   1132.600    373.300   1135.300    387.800       .000       .000
1
 11-27-90    12:49:48                                                                                  PAGE   15


NH      4.000       .040     92.400       .030    180.900       .040    229.500       .100    314.700       .000
X1     52.000     46.000     92.400    180.900    520.000    560.000    540.000       .000       .000       .000
GR   1137.300       .000   1136.600      7.200   1133.200     25.000   1131.400     45.200   1131.000     68.500
GR   1130.200     76.100   1128.600     86.500   1127.300     91.000   1126.400     92.400   1124.400     96.700
GR   1123.400     99.200   1123.500    102.300   1123.200    107.900   1123.000    112.300   1123.000    117.300
GR   1123.100    119.200   1123.400    124.200   1123.400    125.400   1123.700    134.800   1123.700    142.900
GR   1123.700    151.000   1123.700    159.800   1123.700    167.900   1123.700    174.800   1123.800    177.900
GR   1124.400    180.900   1125.200    187.000   1125.500    192.500   1125.200    195.400   1125.500    201.100
GR   1126.100    202.600   1126.200    207.200   1125.100    212.800   1125.100    214.500   1126.200    217.200
GR   1126.500    225.000   1126.300    229.500   1126.900    234.600   1127.500    247.700   1127.800    253.400
GR   1128.100    280.100   1128.100    290.700   1128.800    297.400   1129.200    300.000   1134.500    311.900
GR   1136.000    314.700       .000       .000       .000       .000       .000       .000       .000       .000

NH      4.000       .040     19.300       .030     71.900       .040    110.800       .100    272.100       .000
X1     53.000     43.000     19.300     71.900    425.000    425.000    425.000       .000       .000       .000
GR   1137.400       .000   1137.200      1.400   1128.700     12.700   1126.500     14.900   1125.300     18.600
GR   1125.700     19.300   1125.300     20.500   1124.300     23.500   1124.400     25.700   1124.400     27.900
GR   1124.300     34.900   1124.200     36.700   1123.700     39.800   1123.700     41.600   1123.700     44.600
GR   1123.700     46.800   1123.600     50.400   1123.700     53.000   1123.700     54.800   1123.800     58.800
GR   1123.900     61.400   1123.900     63.600   1124.000     65.400   1124.100     67.100   1124.600     68.900
GR   1125.300     71.900   1125.900     81.600   1125.900     92.600   1126.300    110.800   1125.800    124.700
GR   1126.700    126.200   1126.800    126.900   1127.300    128.300   1127.700    134.100   1128.400    140.600
GR   1128.700    141.000   1129.300    158.000   1130.200    170.900   1130.900    181.100   1132.500    205.400
GR   1133.600    224.400   1135.700    249.500   1137.500    272.100       .000       .000       .000       .000

NH      4.000       .050    185.500       .030    309.400       .040    338.000       .125    405.700       .000
X1     54.000     39.000    185.500    309.400    475.000    410.000    465.000       .000       .000       .000
GR   1137.700       .000   1137.100     41.300   1136.000     67.200   1134.800     94.600   1134.500    100.800
GR   1133.200    110.200   1130.900    122.500   1129.900    135.100   1129.100    142.300   1128.700    148.900
GR   1128.700    165.100   1128.500    171.600   1128.400    173.100   1127.900    176.600   1127.200    185.500
GR   1126.400    187.000   1125.900    190.000   1125.700    195.200   1125.500    203.900   1125.500    215.600
GR   1125.300    226.000   1125.400    229.500   1125.500    239.400   1125.500    255.000   1125.800    263.100
GR   1126.600    265.100   1126.700    274.200   1126.400    284.100   1125.900    300.400   1128.000    304.700
GR   1126.300    309.400   1126.700    311.700   1129.700    316.600   1132.200    319.500   1133.000    338.000
GR   1134.000    357.200   1135.600    376.000   1137.200    395.000   1138.200    405.700       .000       .000

NH      5.000       .050    159.900       .030    255.900       .040    280.500       .100    299.300       .040
NH    341.300       .000       .000       .000       .000       .000       .000       .000       .000       .000
X1     55.000     37.000    159.900    255.900    635.000    500.000    570.000       .000       .000       .000
GR   1137.600       .000   1137.100      3.100   1136.900     18.500   1136.600     41.900   1135.900     52.600
GR   1135.500     85.100   1133.200    139.200   1132.600    144.900   1132.100    148.900   1130.400    153.300
GR   1129.600    154.400   1128.700    157.600   1127.900    159.900   1127.700    163.000   1126.900    168.000
GR   1126.700    171.200   1127.000    175.100   1126.900    176.400   1126.900    180.900   1126.800    184.100
GR   1126.700    188.600   1129.900    197.000   1127.000    204.800   1127.000    213.800   1127.000    223.500
GR   1126.900    234.400   1126.900    242.800   1127.100    251.900   1127.700    255.900   1128.300    268.200
GR   1128.300    275.700   1129.800    280.500   1130.700    282.400   1131.500    299.300   1133.100    314.700
GR   1136.600    328.200   1140.500    341.300       .000       .000       .000       .000       .000       .000
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NC       .000       .000       .000       .300       .500       .000       .000       .000       .000       .000
NH      3.000       .040    246.870       .030    349.740       .040    495.900       .000       .000       .000
X1     56.000     48.000    274.300    405.100    120.000    120.000    120.000       .900       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000     36.500     36.100       .000
GR   1137.500       .000   1136.900     41.700   1137.100     73.800   1137.200     97.800   1136.900    145.100
GR   1136.600    178.200   1136.200    211.800   1136.200    238.600   1135.600    260.300   1135.200    264.800
GR   1133.700    269.400   1132.500    274.300   1130.400    279.500   1128.200    282.700   1129.500    291.500
GR   1127.900    296.400   1127.300    299.400   1126.800    305.500   1126.800    308.400   1126.900    311.300
GR   1126.900    313.100   1126.900    317.500   1127.200    322.900   1127.800    326.900   1127.900    329.500
GR   1127.400    332.500   1127.200    337.000   1126.700    345.400   1126.800    355.700   1126.900    358.300
GR   1127.100    369.200   1127.400    375.000   1127.900    379.000   1130.500    388.600   1134.200    388.600
GR   1134.200    392.000   1131.200    392.200   1134.100    399.200   1134.700    405.100   1135.400    412.600
GR   1135.200    428.800   1133.100    459.900   1132.800    476.500   1130.700    494.900   1131.600    516.400
GR   1134.800    527.500   1136.600    530.600   1141.600    551.000       .000       .000       .000       .000

SB      1.050      1.000      2.600       .000     85.500      4.500    750.000      2.000   1126.900   1126.900
NH      3.000       .040    370.170       .030    477.720       .040    547.740       .000       .000       .000
X1     58.000     40.000    411.300    530.800      7.000      7.000      7.000       .900       .000       .000
X2       .000       .000      1.000   1135.000   1136.000       .000       .000      1.330       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1136.500   1136.100       .000
GR   1138.900       .000   1138.200    112.000   1137.100    221.200   1136.500    338.600   1135.700    398.900
GR   1136.000    399.700   1134.400    409.800   1134.000    410.500   1133.800    411.300   1133.500    413.900
GR   1133.300    415.800   1133.100    417.300   1132.500    418.100   1132.200    419.000   1131.300    419.200
GR   1130.800    420.100   1130.200    421.500   1128.100    425.800   1127.800    429.800   1127.000    433.800
GR   1126.800    440.000   1126.400    448.500   1126.500    450.800   1126.400    453.100   1126.700    470.000
GR   1127.200    478.500   1126.700    486.200   1126.600    495.500   1126.800    503.200   1126.800    508.600
GR   1127.200    517.800   1127.800    522.800   1131.000    530.800   1131.700    534.200   1132.000    535.800
GR   1134.100    540.500   1134.500    544.600   1135.500    574.200   1136.100    595.700   1136.200    608.600

NH      3.000       .040    357.600       .030    450.500       .040    478.500       .000       .000       .000
X1     59.000     30.000    357.600    450.500     10.000     45.000     20.000       .000       .000       .000
GR   1139.500       .000   1138.100     89.300   1137.000    166.600   1136.600    225.800   1136.400    287.600
GR   1134.800    321.000   1134.400    344.400   1134.400    345.400   1134.100    350.500   1131.900    354.500
GR   1131.000    355.300   1130.500    355.700   1128.600    357.600   1128.000    360.700   1127.400    365.700
GR   1127.200    372.900   1126.700    377.600   1126.900    387.200   1127.000    403.100   1126.900    415.100
GR   1126.800    423.000   1127.000    430.900   1127.100    438.900   1128.000    441.900   1128.700    450.500
GR   1130.700    454.900   1130.900    456.400   1134.500    464.000   1135.900    471.700   1136.000    478.500
EJ       .000       .000       .000       .000       .000       .000       .000       .000       .000       .000
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *PROF 1

 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.

 CCHV=    .100 CEHV=    .300
 1490 NH CARD USED
 *SECNO 1.000
      1.00      4.40   1090.60       .00   1090.60   1090.94       .34       .00       .00   1091.20
     1960.        0.     1960.        0.        0.      755.        0.        0.        0.    1090.40
       .00       .00      2.60       .01      .000      .026      .035      .000   1086.20    212.59
   .001317        0.        0.        0.         0         0         0       .00    296.01    508.60
0
 1490 NH CARD USED
 *SECNO 2.000
      2.00      4.61   1091.21       .00       .00   1091.64       .43       .67       .03   1090.80
     1960.        0.     1960.        0.        0.      677.        0.      293.      125.    1090.50
       .04       .01      2.90       .50      .035      .026      .035      .000   1086.60     58.78
   .002034      410.      410.      410.         2         0         0       .00    313.14    371.92
0
 1490 NH CARD USED
 *SECNO 3.000

 3301 HV CHANGED MORE THAN HVINS

      3.00      5.21   1091.61   1091.49       .00   1092.56       .95       .77       .16   1091.70
     1960.        0.     1680.      280.        0.      363.      175.      491.      219.    1090.10
       .06       .00      4.62      1.60      .035      .026      .036      .000   1086.40    104.39
   .002729      325.      325.      325.         4         8         0       .00    269.10    373.49
0
 1490 NH CARD USED
 *SECNO 4.000
      4.00      5.27   1093.27       .00       .00   1093.98       .70      1.39       .02   1091.50
     1960.      126.     1828.        5.      140.      476.        4.      904.      408.    1090.60
       .12       .90      3.84      1.27      .043      .026      .036      .000   1088.00    117.59
   .001501      710.      720.      690.         1         0         0       .00    264.19    381.78
0
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 1490 NH CARD USED
 *SECNO 5.000
      5.00      5.56   1093.66       .00       .00   1094.22       .56       .23       .01   1090.80
     1960.      159.     1794.        7.      195.      518.        6.     1031.      464.    1090.40
       .13       .82      3.46      1.19      .041      .026      .036      .000   1088.10     52.80
   .001024      200.      185.      180.         1         0         0       .00    315.51    368.31
0
 1490 NH CARD USED
```

```
*SECNO 6.000
     6.00      6.04  1094.34       .00       .00  1094.77       .43       .54       .01  1092.60
    1960.      117.    1834.        9.      152.     609.        7.     1416.      621.   1090.90
      .18       .77     3.01      1.24      .043     .026      .035      .000   1088.30    26.31
  .001041      480.     530.      550.         2        0         0       .00    309.09   335.40
0
1490 NH CARD USED
*SECNO 7.000

3301 HV CHANGED MORE THAN HVINS

     7.00      4.66  1094.76       .00       .00  1095.85      1.08       .88       .19  1091.90
    1960.       20.    1880.       60.        9.     401.       34.     1741.      742.   1091.50
      .21      2.19     4.69      1.76      .035     .026      .037      .000   1090.10    41.95
  .002267      590.     530.      480.         2        0         0       .00    130.76   172.71
0
1490 NH CARD USED
*SECNO 8.000
     8.00      5.86  1095.86   1095.56       .00  1097.21      1.35      1.29       .08  1094.70
    1960.       88.    1871.        1.       79.     355.        2.     1982.      824.   1092.50
      .24      1.12     5.27       .33      .043     .026      .108      .000   1090.00   148.69
  .002484      640.     540.      470.         4        8         0       .00    163.25   311.94
0
1490 NH CARD USED
*SECNO 9.000

3301 HV CHANGED MORE THAN HVINS

     9.00      6.67  1097.27       .00       .00  1097.81       .53       .51       .08  1094.20
    1960.       50.    1895.       14.       49.     576.       11.     2186.      885.   1092.80
      .28      1.03     3.29      1.33      .043     .026      .036      .000   1090.60   127.09
  .000926      380.     380.      380.         2        0         0       .00    157.19   284.29
0
1
  11-27-90     12:49:48                                                                                                  PAGE   19


     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


1490 NH CARD USED
*SECNO 10.000
    10.00      5.33  1097.53       .00       .00  1098.40       .87       .49       .10  1094.50
    1950.        8.    1849.       92.        6.     436.      179.     2437.      973.   1093.80
      .30      1.40     4.24       .52      .035     .026      .077      .000   1092.20    86.77
  .001518      360.     400.      410.         2        0         0       .00    279.65   366.42
0
1490 NH CARD USED
*SECNO 11.000

3265 DIVIDED FLOW

    11.00      4.59  1098.59       .00       .00  1099.04       .45       .60       .04  1097.50
    1950.        0.    1929.       20.        1.     648.       20.     2772.     1107.   1096.00
      .35       .40     2.98       .99      .035     .026      .037      .000   1094.00   127.11
  .000947      460.     510.      570.         2        0         0       .00    219.79   347.81
0
1490 NH CARD USED
*SECNO 12.000
    12.00      4.60  1098.90       .00       .00  1099.55       .65       .45       .06  1096.30
    1950.      375.    1569.        6.      203.     405.        4.     3008.     1186.   1095.90
      .38      1.85     3.87      1.42      .035     .026      .035      .000   1094.30   134.00
  .001583      360.     370.      370.         2        0         0       .00    208.43   342.43
0
1490 NH CARD USED
*SECNO 13.000
    13.00      4.92  1099.62       .00       .00  1100.65      1.03       .99       .12  1096.80
    1950.      138.    1794.       18.       59.     386.        8.     3288.     1273.   1096.40
      .41      2.33     4.64      2.28      .035     .026      .035      .000   1094.70   270.66
  .002203      510.     530.      550.         2        0         0       .00    124.79   395.44
0
1490 NH CARD USED
*SECNO 14.000
    14.00      4.90  1100.60       .00       .00  1101.22       .61       .52       .04  1097.60
    1950.       12.    1922.       16.       10.     552.       10.     3455.     1321.   1097.10
      .44      1.15     3.48      1.52      .035     .026      .036      .000   1095.70   115.51
  .001272      325.     325.      325.         2        0         0       .00    169.22   284.74
0
1
  11-27-90     12:49:48                                                                                                  PAGE   20


     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


1490 NH CARD USED
*SECNO 15.000

3265 DIVIDED FLOW

    15.00      5.74  1100.94       .00       .00  1102.00      1.06       .65       .14  1098.20
    1950.        7.    1622.      321.        5.     330.      152.     3659.     1387.   1097.80
      .47      1.46     4.92      2.11      .035     .026      .037      .000   1095.20    18.05
  .002215      390.     390.      370.         2        0         0       .00    175.19   264.44
0
1490 NH CARD USED
*SECNO 16.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    16.00      3.75  1103.15   1103.15       .00  1104.58      1.43      1.98      -.36  1104.00
    1950.        0.    1783.      167.        0.     325.       62.     3869.     1463.   1101.00
      .49       .00     5.48      2.69      .043     .026      .035      .000   1099.40    12.15
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   .004193      465.      465.      520.        10        14         0       .00    137.03    149.18
0
 1490 NH CARD USED
 *SECNO 17.000

 3301 HV CHANGED MORE THAN HVINS

     17.00      5.80   1104.90       .00       .00   1105.19       .28       .49       .11   1100.80
     1950.       10.     1860.       80.       13.      772.       89.     4276.     1585.   1100.40
       .57       .75      2.41       .90      .043      .026      .035      .000   1099.10     22.59
   .000420      680.      650.      620.         3         0         0       .00    241.79    264.37
0
 1490 NH CARD USED
 *SECNO 18.000
     18.00      6.40   1105.00       .00       .00   1105.64       .64       .35       .11   1101.20
     1950.      444.     1496.       10.      288.      377.        8.     4678.     1698.   1101.20
       .61      1.54      3.97      1.29      .043      .026      .035      .000   1098.60    132.75
   .001068      570.      510.      470.         3         0         0       .00    195.06    327.81
0
 1490 NH CARD USED
 *SECNO 19.000
     19.00      5.41   1105.51       .00       .00   1106.36       .85       .66       .06   1102.20
     1950.      123.     1810.       17.       75.      430.        9.     4977.     1781.   1102.20
       .64      1.64      4.21      1.97      .043      .026      .035      .000   1100.10    200.19
   .001530      490.      510.      520.         2         0         0       .00    136.22    336.41
0
1
  11-27-90     12:49:48                                                                                   PAGE   21


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


 1490 NH CARD USED
 *SECNO 20.000
     20.00      6.15   1106.25       .00       .00   1106.91       .66       .53       .02   1102.20
     1940.      176.     1756.        8.      117.      468.        7.     5212.     1850.   1102.30
       .68      1.51      3.75      1.15      .035      .026      .035      .000   1100.10    161.21
   .001019      360.      440.      450.         2         0         0       .00    206.53    367.75
0
 1490 NH CARD USED
 *SECNO 21.000

 3265 DIVIDED FLOW

     21.00      4.45   1106.65       .00       .00   1107.73      1.07       .69       .12   1104.70
     1940.       12.     1922.        6.       14.      417.        4.     5431.     1922.   1103.60
       .70       .87      4.61      1.38      .043      .026      .035      .000   1102.20    103.99
   .002215      390.      430.      460.         2         0         0       .00    139.74    350.07
0
 1490 NH CARD USED
 *SECNO 22.000

 3301 HV CHANGED MORE THAN HVINS

     22.00      4.74   1107.84       .00       .00   1108.33       .48       .54       .06   1104.30
     1940.      174.     1755.       11.      131.      546.        9.     5658.     1991.   1104.40
       .74      1.33      3.21      1.29      .043      .026      .035      .000   1103.10     84.98
   .000946      375.      410.      430.         2         0         0       .00    207.66    292.65
0
 1490 NH CARD USED
 *SECNO 23.000
     23.00      4.74   1108.14       .00       .00   1109.02       .88       .57       .12   1105.40
     1940.        4.     1924.       12.        3.      462.        8.     5895.     2062.   1105.10
       .77      1.07      4.17      1.60      .043      .026      .035      .000   1103.40     17.32
   .002073      405.      410.      415.         2         0         0       .00    141.18    158.50
0
 1490 NH CARD USED
 *SECNO 24.000
     24.00      4.31   1108.91       .00       .00   1109.86       .95       .82       .02   1108.50
     1940.        0.     1870.       70.        0.      426.       51.     6076.     2119.   1106.10
       .79       .00      4.39      1.39      .108      .026      .052      .000   1104.60     16.10
   .002251      375.      380.      385.         2         0         0       .00    154.89    170.99
0
1
  11-27-90     12:49:48                                                                                   PAGE   22


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


 1490 NH CARD USED
 *SECNO 25.000
     25.00      4.72   1110.22       .00       .00   1110.74       .52       .83       .04   1106.80
     1940.      482.     1451.        7.      193.      427.        6.     6392.     2211.   1106.70
       .84      2.49      3.40      1.20      .029      .026      .035      .000   1105.50     58.69
   .001068      575.      575.      550.         2         0         0       .00    168.89    227.58
0
 1490 NH CARD USED
 *SECNO 26.000
     26.00      4.99   1110.39       .00       .00   1111.30       .91       .44       .12   1107.40
     1940.      430.     1490.       21.      270.      315.       10.     6574.     2277.   1107.00
       .87      1.59      4.74      2.17      .040      .026      .035      .000   1105.40     41.95
   .002065      305.      295.      280.         2         0         0       .00    267.71    309.66
0
 1490 NH CARD USED
 *SECNO 27.000

 3301 HV CHANGED MORE THAN HVINS

     27.00      4.96   1111.46       .00       .00   1111.84       .38       .49       .05   1108.10
     1940.      567.     1373.        0.      346.      448.        0.     6834.     2371.   1111.70
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       .90      1.64      3.06       .00      .036      .026      .035      .000  1106.50     46.45
   .000948      360.      385.      390.         2         0         0       .00   240.79    287.24
0
 1490 NH CARD USED
 *SECNO 28.000

 3301 HV CHANGED MORE THAN HVINS

 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     28.00      4.52  1111.82   1111.82       .00  1113.66      1.85      2.51      -.88  1113.30
     1940.        0.     1875.       65.        0.      307.       22.     7172.     2471.   1108.80
       .93       .00      6.10      3.00      .087      .026      .035      .000  1107.30     62.31
   .004236      640.      585.      540.         3        11         0       .00     91.31    153.62
0
 1490 NH CARD USED
 *SECNO 29.000
1
  11-27-90     12:49:48                                                                                  PAGE   23

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 3301 HV CHANGED MORE THAN HVINS

     29.00      5.00  1113.90       .00       .00  1114.16       .25       .34       .16  1110.40
     1940.       99.     1804.       37.      112.      784.       27.     7430.     2536.   1109.60
       .98       .89      2.30      1.39      .043      .026      .035      .000  1108.90    117.38
   .000458      500.      410.      275.         2         0         0       .00   223.45    340.82
0
 1490 NH CARD USED
 *SECNO 30.000

 3265 DIVIDED FLOW

     30.00      4.33  1114.13       .00       .00  1114.54       .41       .33       .05  1112.30
     1934.      398.     1499.       37.      279.      476.       23.     7798.     2642.   1111.30
      1.03      1.43      3.15      1.62      .043      .026      .035      .000  1109.80     99.37
   .001118      500.      415.      350.         2         0         0       .00   255.07    387.62
0
 1490 NH CARD USED
 *SECNO 31.000

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS

     31.00      6.72  1114.02       .00       .00  1115.46      1.44       .61       .31  1111.90
     1934.        9.     1923.        2.       10.      361.        4.     8005.     2710.   1111.50
      1.04       .89      5.33       .52      .043      .026      .087      .000  1107.30    359.87
   .002664      390.      350.      345.         2         0         0       .00   115.46    498.32
0
 1490 NH CARD USED
 *SECNO 32.000

 3301 HV CHANGED MORE THAN HVINS

     32.00      4.44  1116.04       .00       .00  1116.78       .74      1.25       .07  1113.80
     1934.        9.     1884.       41.        7.      489.       21.     8284.     2789.   1113.20
      1.09      1.28      3.85      1.92      .035      .026      .035      .000  1111.60    342.74
   .001604      525.      625.      700.         2         0         0       .00   141.32    484.06
0
1
  11-27-90     12:49:48                                                                                  PAGE   24

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 1490 NH CARD USED
 *SECNO 33.000
     33.00      4.55  1116.45       .00       .00  1117.42       .96       .57       .07  1114.40
     1934.        2.     1875.       57.        2.      426.       27.     8435.     2830.   1113.40
      1.11      1.05      4.41      2.11      .035      .026      .035      .000  1111.90    105.74
   .002106      315.      310.      305.         2         0         0       .00   126.27    232.02
0
 1490 NH CARD USED
 *SECNO 34.000
     34.00      5.31  1117.31       .00       .00  1118.23       .92       .80       .00  1114.80
     1934.        0.     1433.      501.        1.      303.      216.     8624.     2886.   1114.00
      1.14       .36      4.73      2.32      .035      .026      .035      .000  1112.00     85.01
   .002024      390.      390.      390.         3         0         0       .00   160.97    245.98
0
 1490 NH CARD USED
 *SECNO 35.000
     35.00      4.70  1118.10       .00       .00  1118.77       .68       .52       .02  1114.90
     1934.       21.     1829.       84.       14.      491.       44.     8782.     2934.   1115.10
      1.16      1.51      3.72      1.92      .035      .026      .035      .000  1113.40    125.69
   .001563      295.      295.      295.         2         0         0       .00   161.93    287.61
0
 CCHV=     .300 CEHV=     .500
 1490 NH CARD USED
 *SECNO 36.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1120.20 ELREA=     1121.40

     36.00      4.24  1118.14       .00       .00  1118.90       .76       .09       .04  1119.70
     1934.        0.     1934.        0.        0.      501.        0.     8808.     2942.   1121.00
      1.16       .00      3.86       .00      .035      .026      .035      .000  1113.90    217.80
```

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   .002031       50.       50.       50.         2         0         0       .00    147.49    365.29
0
 1490 NH CARD USED
 *SECNO 37.100

 3265 DIVIDED FLOW

1
  11-27-90    12:49:48                                                                                              PAGE    25

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 3370 NORMAL BRIDGE,NRD=  3 MIN ELTRD= 1120.40 MAX ELLC= 1120.50

     37.10      4.01   1118.11       .00       .00   1118.94       .82       .00       .03   1120.30
     1934.        0.     1934.        0.        0.      481.        0.     8809.     2942.   1120.50
      1.16       .00      4.02       .00      .035      .024      .035      .000   1114.10    100.00
   .002069        1.        1.        1.         2         0         0       .00    142.29    244.29
0
 1490 NH CARD USED
 *SECNO 37.200

 3265 DIVIDED FLOW


 3370 NORMAL BRIDGE,NRD=  3 MIN ELTRD= 1120.40 MAX ELLC= 1120.50

     37.20      4.04   1118.14       .00       .00   1118.96       .81       .02       .00   1120.30
     1934.        0.     1934.        0.        0.      484.        0.     8813.     2943.   1120.50
      1.16       .00      4.00       .00      .035      .024      .035      .000   1114.10    100.00
   .002027        8.        8.        8.         1         0         0       .00    142.30    244.30
0
 1490 NH CARD USED
 *SECNO 38.000
     38.00      4.09   1118.29       .00       .00   1118.99       .70       .00       .03   1120.10
     1934.        0.     1934.        0.        0.      520.        0.     8813.     2943.   1120.60
      1.16       .00      3.72       .00      .035      .026      .035      .000   1114.20    177.60
   .001758        1.        1.        1.         2         0         0       .00    143.88    321.48
0
 1490 NH CARD USED
 *SECNO 39.000
     39.00      4.28   1118.48       .00       .00   1119.08       .61       .06       .03   1115.90
     1934.       33.     1879.       22.       25.      538.       16.     8835.     2950.   1115.40
      1.17      1.32      3.49      1.36      .035      .026      .043      .000   1114.20    259.10
   .001345       40.       40.       40.         2         0         0       .00    171.56    430.66
0
 CCHV=    .100 CEHV=    .300
 1490 NH CARD USED
 *SECNO 40.000
1
  11-27-90    12:49:48                                                                                              PAGE    26

     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 3301 HV CHANGED MORE THAN HVINS

     40.00      4.53   1118.73       .00       .00   1119.85      1.11       .61       .15   1115.90
     1934.      205.     1715.       14.       90.      350.        7.     9004.     3003.   1115.90
      1.19      2.28      4.90      2.09      .035      .026      .035      .000   1114.20    517.80
   .002563      325.      330.      335.         2         0         0       .00    153.74    671.54
0
 1490 NH CARD USED
 *SECNO 41.000

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS

     41.00      6.01   1119.91       .00       .00   1120.36       .46       .45       .07   1116.60
     1934.       22.     1902.        9.       18.      629.        9.     9231.     3062.   1115.60
      1.23      1.20      3.03      1.06      .035      .026      .035      .000   1113.90    370.83
   .000695      385.      415.      450.         2         0         0       .00    136.35    559.82
0
 1490 NH CARD USED
 *SECNO 42.000

 3301 HV CHANGED MORE THAN HVINS

     42.00      4.97   1119.77   1119.71       .00   1121.33      1.57       .64       .33   1117.40
     1934.       27.     1819.       88.       11.      320.       39.     9388.     3103.   1117.10
      1.24      2.55      5.69      2.27      .035      .026      .035      .000   1114.80    374.48
   .003467      245.      305.      365.         4        12         0       .00    123.06    497.54
0
 1490 NH CARD USED
 *SECNO 43.000

 3301 HV CHANGED MORE THAN HVINS

     43.00      4.88   1121.78       .00       .00   1122.29       .51       .85       .11   1119.50
     1934.      139.     1768.       28.      107.      536.       41.     9676.     3194.   1118.30
      1.29      1.30      3.30       .68      .035      .026      .087      .000   1116.90     95.76
   .001003      600.      545.      495.         2         0         0       .00    210.55    306.31
0
1
  11-27-90    12:49:48                                                                                              PAGE    27
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 1490 NH CARD USED
 *SECNO 44.000

 3301 HV CHANGED MORE THAN HVINS

      44.00      4.87  1122.07       .00       .00  1123.10      1.03       .66       .16  1119.40
      1913.      275.    1638.        0.      119.     343.        0.     9923.     3270.   1122.00
       1.32      2.31     4.78       .01      .035      .026      .035      .000   1117.20   201.59
    .002322      435.     430.      425.         3         0         0       .00    141.83   343.42
0
 CCHV=    .300 CEHV=    .500
 1490 NH CARD USED
 *SECNO 45.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1127.00 ELREA=     1127.00

      45.00      5.29  1122.39  1122.39       .00  1123.90      1.51       .41       .11  1124.90
      1913.        0.    1913.        0.        0.     351.        0.     9960.     3282.   1125.60
       1.32       .00     5.45       .00      .035      .026      .035      .000   1117.10   234.03
    .004732      120.      85.       60.         3         8         0       .00    118.88   352.90
0

 SPECIAL BRIDGE

 5227 DOWNSTREAM ELEV IS   1122.05 ,NOT   1122.39 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

 SB  XK         XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
       .90       1.00       2.60        .00     100.00       3.00     740.00       3.00    1119.20    1119.20

 1490 NH CARD USED
 1490 NH CARD USED
 *SECNO 47.000
 6110 EGLWC OF 1123.79 LESS THAN XEG OF 1123.90

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS

1
  11-27-90     12:49:48                                                                                    PAGE   28

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

 CLASS B LOW FLOW

 3420 BRIDGE W.S.=   1122.49 BRIDGE VELOCITY=,       5.43       CALCULATED CHANNEL AREA=,       352.

  EGPRS       EGLWC        H3        QWEIR        QLOW       BAREA    TRAPEZOID       ELLC       ELTRD
                                                                       AREA
        .00   1123.79        .00         0.      1913.       740.       744.      1125.60    1127.60


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1127.60 ELREA=     1127.60

      47.00      6.46  1123.06       .00       .00  1123.90       .73       .00       .00  1125.00
      1913.        0.    1913.        0.        0.     504.        0.     9965.     3284.   1125.70
       1.32       .00     3.79       .00      .000      .026      .000      .000   1116.60   242.59
    .001497       13.      13.       13.         0         0         0       .00    120.85   364.28
0
 1490 NH CARD USED
 *SECNO 48.000
      48.00      6.40  1123.60       .00       .00  1124.14       .54       .18       .06  1121.20
      1913.      553.    1360.        1.      311.     368.        1.    10048.     3306.   1122.90
       1.33      1.77     3.69       .56      .037      .026      .035      .000   1117.20   176.03
    .001082      125.     145.      165.         2         0         0       .00    193.70   369.73
0
 CCHV=    .100 CEHV=    .300
 1490 NH CARD USED
 *SECNO 49.000
      49.00      5.21  1124.11       .00       .00  1124.44       .32       .27       .02  1121.10
      1913.       54.    1661.      198.       50.     626.      152.    10311.     3380.   1121.10
       1.37      1.09     2.65      1.31      .043      .026      .035      .000   1118.90    88.11
    .000611      330.     355.      350.         2         0         0       .00    234.18   322.29
0
 1490 NH CARD USED
 *SECNO 49.100

 3265 DIVIDED FLOW


 3301 HV CHANGED MORE THAN HVINS

1
  11-27-90     12:49:48                                                                                    PAGE   29

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST
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 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     49.10     4.75  1124.05  1124.05      .00  1125.76     1.71     1.62     -.57  1122.70
     1913.       1.    1863.      49.       1.     317.      50.   10555.    3457.   1121.50
      1.39     1.19     5.87      .99     .035     .026     .085     .000  1119.30     8.39
   .003990     395.     405.     425.        4       11        0      .00   141.35   220.47
0
 1490 NH CARD USED
 *SECNO 50.000

 3301 HV CHANGED MORE THAN HVINS

     50.00     5.15  1125.95      .00      .00  1126.40      .45      .52      .13  1123.40
     1913.       7.    1588.     318.       6.     493.     280.   10729.    3531.   1122.90
      1.42     1.13     3.22     1.14     .035     .026     .044     .000  1120.80    26.37
   .000992     400.     335.     225.        2        0        0      .00   420.38   446.75
0
 1490 NH CARD USED
 *SECNO 51.000
     51.00     4.45  1126.45      .00      .00  1127.08      .62      .63      .05  1123.70
     1590.     117.    1402.      71.      74.     382.      34.   11055.    3688.   1123.20
      1.47     1.59     3.67     2.10     .035     .026     .035     .000  1122.00   184.06
   .001476     440.     505.     555.        3        0        0      .00   179.48   363.53
0
 1490 NH CARD USED
 *SECNO 52.000
     52.00     4.27  1127.27      .00      .00  1128.19      .93     1.03      .09  1126.40
     1590.       0.    1429.     161.       1.     321.      82.   11296.    3778.   1124.40
      1.50      .73     4.46     1.95     .035     .026     .035     .000  1123.00    91.05
   .002443     520.     540.     560.        2        0        0      .00   151.53   242.59
0
 1490 NH CARD USED
 *SECNO 53.000

 3301 HV CHANGED MORE THAN HVINS

     53.00     4.57  1128.17  1128.15      .00  1129.62     1.46     1.27      .16  1125.70
     1590.      32.    1255.     303.      12.     213.     127.   11457.    3837.   1125.30
      1.52     2.73     5.89     2.39     .035     .026     .042     .000  1123.60    13.24
   .003666     425.     425.     425.        3        8        0      .00   125.15   138.39
0
1
  11-27-90     12:49:48                                                                                              PAGE   30


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 1490 NH CARD USED
 *SECNO 54.000

 3301 HV CHANGED MORE THAN HVINS

     54.00     4.69  1129.99      .00      .00  1130.41      .43      .69      .10  1127.20
     1590.      68.    1495.      26.      71.     503.      17.   11672.    3907.   1126.30
      1.57      .97     2.97     1.56     .043     .026     .035     .000  1125.30   134.09
   .000937     475.     465.     410.        2        0        0      .00   182.83   316.92
0
 1490 NH CARD USED
 *SECNO 55.000
     55.00     3.95  1130.65      .00      .00  1131.54      .89      .99      .14  1127.90
     1590.      18.    1421.     151.      11.     327.      59.   11954.    3996.   1127.70
      1.61     1.67     4.35     2.57     .043     .026     .035     .000  1126.70   152.66
   .002535     635.     570.     500.        3        0        0      .00   129.63   282.29
0
 CCHV=    .300 CEHV=    .500
 1490 NH CARD USED
 *SECNO 56.000

 3265 DIVIDED FLOW

     56.00     4.13  1130.83      .00      .00  1132.08     1.26      .36      .18  1132.50
     1590.       0.    1590.       0.       0.     320.       0.   11997.    4010.   1134.70
      1.61      .00     4.97      .21     .043     .026     .035     .000  1126.70   250.60
   .003600     120.     120.     120.        2        0        0      .00   102.86   448.13
0

 SPECIAL BRIDGE

 SB  XK        XKOR       COFQ       RDLEN      BWC        BWP        BAREA      SS         ELCHU      ELCHD
      1.05      1.00       2.60        .00      85.50       4.50     750.00       2.00    1126.90    1126.90

 1490 NH CARD USED
 *SECNO 58.000
 6110 EGLWC OF 1132.06 LESS THAN XEG OF 1132.08
 CLASS A LOW FLOW

 3420 BRIDGE W.S.=    1130.51 BRIDGE VELOCITY=,       5.00      CALCULATED CHANNEL AREA=,       318.
1
  11-27-90     12:49:48                                                                                              PAGE   31


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


  EGPRS      EGLWC       H3       QWEIR      QLOW       BAREA   TRAPEZOID      ELLC      ELTRD
                                                                  AREA
       .00   1132.06       .46        0.     1590.       750.       787.    1135.00   1136.00
```

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 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA-      1136.50 ELREA-      1136.10

    58.00     4.89 1131.29       .00      .00  1132.08      .77       .00      .00  1133.80
    1590.       0.   1590.        0.       0.     410.       0.    11999.    4011.  1131.00
     1.61      .00    3.88       .00     .000     .026     .000      .000  1126.40   377.29
  .001594       7.      7.        7.        0        0        0       .00   100.43   477.72
0
 1490 NH CARD USED
 *SECNO 59.000
    59.00     4.61 1131.31       .00      .00  1132.16      .86       .03      .04  1128.60
    1590.       5.   1574.       12.       4.     382.       8.    12007.    4013.  1128.70
     1.62     1.33    4.12      1.45     .035     .026     .035      .000  1126.70   355.03
  .001748      10.     20.       45.        2        0        0       .00   102.23   457.26
0
1
  11-27-90     12:49:48                                                                                                       PAGE    32



                                                                                     THIS RUN EXECUTED 11-27-90
 ****************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ****************************************************


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


 BOW RIVER

 SUMMARY PRINTOUT


      SECNO     DEPTH    TOPWID      AREA       VCH         Q      QLOB       QCH      QROB    K*XNCH     CWSEL

       1.000      4.40    296.01    754.59      2.60   1960.00       .00   1960.00       .00     26.01   1090.60
       2.000      4.61    313.14    676.85      2.90   1960.00       .00   1959.89       .11     26.01   1091.21
       3.000      5.21    269.10    538.25      4.62   1960.00       .00   1679.53    280.47     26.01   1091.61
       4.000      5.27    264.19    619.85      3.84   1960.00    126.33   1828.31      5.36     26.01   1093.27
       5.000      5.56    315.51    718.76      3.46   1960.00    159.26   1793.83      6.91     26.01   1093.66
       6.000      6.04    309.09    767.96      3.01   1960.00    117.22   1833.71      9.07     26.01   1094.34
       7.000      4.66    130.76    444.17      4.69   1960.00     19.97   1879.81     60.22     26.13   1094.76
       8.000      5.86    163.25    435.93      5.27   1960.00     88.11   1871.18       .71     26.12   1095.86
       9.000      6.67    157.19    636.28      3.29   1960.00     50.43   1895.08     14.49     26.01   1097.27
      10.000      5.33    279.65    620.80      4.24   1950.00      8.37   1849.44     92.18     26.15   1097.53
      11.000      4.59    219.79    669.70      2.98   1950.00       .37   1929.38     20.25     26.01   1098.59
      12.000      4.60    208.43    612.47      3.87   1950.00    375.37   1568.72      5.91     26.01   1098.90
      13.000      4.92    124.79    453.27      4.64   1950.00    138.13   1794.27     17.60     26.01   1099.62
      14.000      4.90    169.22    572.59      3.48   1950.00     11.69   1922.31     16.00     26.01   1100.60
      15.000      5.74    175.19    486.46      4.92   1950.00      7.31   1621.88    320.81     26.01   1100.94
*     16.000      3.75    137.03    387.31      5.48   1950.00       .00   1783.42    166.58     26.01   1103.15
      17.000      5.80    241.79    873.30      2.41   1950.00      9.65   1860.18     80.17     26.01   1104.90
      18.000      6.40    195.06    673.12      3.97   1950.00    443.83   1495.81     10.36     26.01   1105.00
      19.000      5.41    136.22    513.91      4.21   1950.00    123.06   1809.67     17.27     26.01   1105.51
      20.000      6.15    206.53    591.17      3.75   1940.00    176.49   1755.84      7.67     26.01   1106.25
      21.000      4.45    139.74    435.40      4.61   1940.00     12.37   1921.79      5.83     26.01   1106.65
      22.000      4.74    207.66    685.62      3.21   1940.00    173.69   1755.07     11.24     26.01   1107.84
      23.000      4.74    141.18    472.86      4.17   1940.00      3.73   1923.78     12.49     26.01   1108.14
      24.000      4.31    154.89    476.76      4.39   1940.00       .00   1869.59     70.41     26.01   1108.91
      25.000      4.72    168.89    626.71      3.40   1940.00    482.12   1450.57      7.31     26.01   1110.22
      26.000      4.99    267.71    593.87      4.74   1940.00    429.57   1489.72     20.71     26.01   1110.39
      27.000      4.96    240.79    794.44      3.06   1940.00    567.02   1372.98       .00     26.01   1111.46
*     28.000      4.52     91.31    329.17      6.10   1940.00       .00   1874.53     65.47     26.01   1111.82
      29.000      5.00    223.45    922.29      2.30   1940.00     98.90   1804.13     36.97     26.01   1113.90
      30.000      4.33    255.07    777.79      3.15   1934.00    398.43   1498.54     37.03     26.01   1114.13
      31.000      6.72    115.46    374.54      5.33   1934.00      8.97   1923.22      1.81     26.01   1114.02
      32.000      4.44    141.32    517.38      3.85   1934.00      8.77   1884.46     40.77     26.01   1116.04
      33.000      4.55    126.27    454.64      4.41   1934.00      2.11   1874.75     57.13     26.01   1116.45
      34.000      5.31    160.97    519.25      4.73   1934.00       .23   1432.66    501.10     26.01   1117.31
      35.000      4.70    161.93    548.86      3.72   1934.00     20.86   1828.88     84.27     26.01   1118.10
      36.000      4.24    147.49    500.51      3.86   1934.00       .00   1934.00       .00     26.01   1118.14
      37.100      4.01    142.29    480.52      4.02   1934.00       .00   1934.00       .00     24.28   1118.11
      37.200      4.04    142.30    483.58      4.00   1934.00       .00   1934.00       .00     24.28   1118.14
      38.000      4.09    143.88    519.97      3.72   1934.00       .00   1934.00       .00     26.01   1118.29
      39.000      4.28    171.56    578.94      3.49   1934.00     33.33   1878.87     21.80     26.01   1118.48
      40.000      4.53    153.74    446.53      4.90   1934.00    204.83   1715.11     14.06     26.01   1118.73
      41.000      6.01    136.35    655.89      3.03   1934.00     22.09   1902.50      9.41     26.01   1119.91
      42.000      4.97    123.06    368.87      5.69   1934.00     26.85   1819.20     87.96     26.01   1119.77
      43.000      4.88    210.55    683.85      3.30   1934.00    138.56   1767.67     27.78     26.01   1121.78
      44.000      4.87    141.83    462.01      4.78   1913.00    275.31   1637.69       .00     26.01   1122.07
*     45.000      5.29    118.88    351.05      5.45   1913.00       .00   1913.00       .00     25.69   1122.39
*     47.000      6.46    120.85    504.24      3.79   1913.00       .00   1913.00       .00     26.01   1123.06
      48.000      6.40    193.70    680.54      3.69   1913.00    552.81   1359.65       .53     26.01   1123.60
      49.000      5.21    234.18    827.49      2.65   1913.00     53.92   1660.58    198.50     26.01   1124.11
*     49.100      4.75    141.35    368.09      5.87   1913.00      1.37   1862.83     48.80     26.01   1124.05
      50.000      5.15    420.38    779.14      3.22   1913.00      7.12   1587.62    318.26     26.01   1125.95
      51.000      4.45    179.48    489.70      3.67   1590.00    117.34   1401.77     70.90     26.01   1126.45
      52.000      4.27    151.53    403.51      4.46   1590.00       .42   1428.82    160.76     26.01   1127.27
      53.000      4.57    125.15    351.73      5.89   1590.00     31.73   1255.40    302.87     26.01   1128.17
      54.000      4.69    182.83    590.19      2.97   1590.00     68.31   1495.46     26.23     26.01   1129.99
      55.000      3.95    129.63    396.65      4.35   1590.00     18.30   1421.18    150.52     26.01   1130.65
      56.000      4.13    102.86    320.36      4.97   1590.00       .00   1589.95       .05     26.01   1130.83
      58.000      4.89    100.43    410.05      3.88   1590.00       .00   1590.00       .00     26.01   1131.29
      59.000      4.61    102.23    393.74      4.12   1590.00      4.78   1573.61     11.61     26.01   1131.31
1
  11-27-90     12:49:48                                                                                                       PAGE    35
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BOW RIVER

SUMMARY PRINTOUT TABLE  150

         SECNO      XLCH     ELTRD      ELLC     ELMIN         Q     CWSEL     CRIWS        EG     10K*S       VCH      AREA      .01K

         1.000       .00       .00       .00   1086.20   1960.00   1090.60       .00   1090.94     13.17      2.60    754.59    540.04
         2.000    410.00       .00       .00   1086.60   1960.00   1091.21       .00   1091.64     20.34      2.90    676.85    434.58
         3.000    325.00       .00       .00   1086.40   1960.00   1091.61   1091.49   1092.56     27.29      4.62    538.25    375.19
         4.000    720.00       .00       .00   1088.00   1960.00   1093.27       .00   1093.98     15.01      3.84    619.85    505.91
         5.000    185.00       .00       .00   1088.10   1960.00   1093.66       .00   1094.22     10.24      3.46    718.76    612.38
         6.000    530.00       .00       .00   1088.30   1960.00   1094.34       .00   1094.77     10.41      3.01    767.96    607.60
         7.000    530.00       .00       .00   1090.10   1960.00   1094.76       .00   1095.85     22.67      4.69    444.17    411.68
         8.000    540.00       .00       .00   1090.00   1960.00   1095.86   1095.56   1097.21     24.84      5.27    435.93    393.30
         9.000    380.00       .00       .00   1090.60   1960.00   1097.27       .00   1097.81      9.26      3.29    636.28    644.15
        10.000    400.00       .00       .00   1092.20   1950.00   1097.53       .00   1098.40     15.18      4.24    620.80    500.42
        11.000    510.00       .00       .00   1094.00   1950.00   1098.59       .00   1099.04      9.47      2.98    669.70    633.58
        12.000    370.00       .00       .00   1094.30   1950.00   1098.90       .00   1099.55     15.83      3.87    612.47    490.14
        13.000    530.00       .00       .00   1094.70   1950.00   1099.62       .00   1100.65     22.03      4.64    453.27    415.44
        14.000    325.00       .00       .00   1095.70   1950.00   1100.60       .00   1101.22     12.72      3.48    572.59    546.75
        15.000    390.00       .00       .00   1095.20   1950.00   1100.94       .00   1102.00     22.15      4.92    486.46    414.32
*       16.000    465.00       .00       .00   1099.40   1950.00   1103.15   1103.15   1104.58     41.93      5.48    387.31    301.16
        17.000    650.00       .00       .00   1099.10   1950.00   1104.90       .00   1105.19      4.20      2.41    873.30    951.50
        18.000    510.00       .00       .00   1098.60   1950.00   1105.00       .00   1105.64     10.68      3.97    673.12    596.80
        19.000    510.00       .00       .00   1100.10   1950.00   1105.51       .00   1106.36     15.30      4.21    513.91    498.46
        20.000    440.00       .00       .00   1100.10   1940.00   1106.25       .00   1106.91     10.19      3.75    591.17    607.78
        21.000    430.00       .00       .00   1102.20   1940.00   1106.65       .00   1107.73     22.15      4.61    435.40    412.19
        22.000    410.00       .00       .00   1103.10   1940.00   1107.84       .00   1108.33      9.46      3.21    685.62    630.58
        23.000    410.00       .00       .00   1103.40   1940.00   1108.14       .00   1109.02     20.73      4.17    472.86    426.14
        24.000    380.00       .00       .00   1104.60   1940.00   1108.91       .00   1109.86     22.51      4.39    476.76    408.89
        25.000    575.00       .00       .00   1105.50   1940.00   1110.22       .00   1110.74     10.68      3.40    626.71    593.75
        26.000    295.00       .00       .00   1105.40   1940.00   1110.39       .00   1111.30     20.65      4.74    593.87    426.89
        27.000    385.00       .00       .00   1106.50   1940.00   1111.46       .00   1111.84      9.48      3.06    794.44    629.99
*       28.000    585.00       .00       .00   1107.30   1940.00   1111.82   1111.82   1113.66     42.36      6.10    329.17    298.06
        29.000    410.00       .00       .00   1108.90   1940.00   1113.90       .00   1114.16      4.58      2.30    922.29    906.02
        30.000    415.00       .00       .00   1109.80   1934.00   1114.13       .00   1114.54     11.18      3.15    777.79    578.29
        31.000    350.00       .00       .00   1107.30   1934.00   1114.02       .00   1115.46     26.64      5.33    374.54    374.70
        32.000    625.00       .00       .00   1111.60   1934.00   1116.04       .00   1116.78     16.04      3.85    517.38    482.93
        33.000    310.00       .00       .00   1111.90   1934.00   1116.45       .00   1117.42     21.06      4.41    454.64    421.48
        34.000    390.00       .00       .00   1112.00   1934.00   1117.31       .00   1118.23     20.24      4.73    519.25    429.88
        35.000    295.00       .00       .00   1113.40   1934.00   1118.10       .00   1118.77     15.63      3.72    548.86    489.17
        36.000     50.00       .00       .00   1113.90   1934.00   1118.14       .00   1118.90     20.31      3.86    500.51    429.14
        37.100      1.00   1120.40   1120.50   1114.10   1934.00   1118.11       .00   1118.94     20.69      4.02    480.52    425.23
        37.200      8.00   1120.40   1120.50   1114.10   1934.00   1118.14       .00   1118.96     20.27      4.00    483.58    429.58
        38.000      1.00       .00       .00   1114.20   1934.00   1118.29       .00   1118.99     17.58      3.72    519.97    461.31
        39.000     40.00       .00       .00   1114.20   1934.00   1118.48       .00   1119.08     13.45      3.49    578.94    527.39
        40.000    330.00       .00       .00   1114.20   1934.00   1118.73       .00   1119.85     25.63      4.90    446.53    382.00
        41.000    415.00       .00       .00   1113.90   1934.00   1119.91       .00   1120.36      6.95      3.03    655.89    733.78
        42.000    305.00       .00       .00   1114.80   1934.00   1119.77   1119.71   1121.33     34.67      5.69    368.87    328.48
        43.000    545.00       .00       .00   1116.90   1934.00   1121.78       .00   1122.29     10.03      3.30    683.85    610.81
        44.000    430.00       .00       .00   1117.20   1913.00   1122.07       .00   1123.10     23.22      4.78    462.01    396.99
*       45.000     85.00       .00       .00   1117.10   1913.00   1122.39   1122.39   1123.90     47.32      5.45    351.05    278.10
*       47.000     13.00   1127.60   1125.60   1116.60   1913.00   1123.06       .00   1123.90     14.97      3.79    504.24    494.41
        48.000    145.00       .00       .00   1117.20   1913.00   1123.60       .00   1124.14     10.82      3.69    680.54    581.45
        49.000    355.00       .00       .00   1118.90   1913.00   1124.11       .00   1124.44      6.11      2.65    827.49    774.10
*       49.100    405.00       .00       .00   1119.30   1913.00   1124.05   1124.05   1125.76     39.90      5.87    368.09    302.87
        50.000    335.00       .00       .00   1120.80   1913.00   1125.95       .00   1126.40      9.92      3.22    779.14    607.36
        51.000    505.00       .00       .00   1122.00   1590.00   1126.45       .00   1127.08     14.76      3.67    489.70    413.87
        52.000    540.00       .00       .00   1123.00   1590.00   1127.27       .00   1128.19     24.43      4.46    403.51    321.70
        53.000    425.00       .00       .00   1123.60   1590.00   1128.17   1128.15   1129.62     36.66      5.89    351.73    262.62
        54.000    465.00       .00       .00   1125.30   1590.00   1129.99       .00   1130.41      9.37      2.97    590.19    519.49
        55.000    570.00       .00       .00   1126.70   1590.00   1130.65       .00   1131.54     25.35      4.35    396.65    315.82
        56.000    120.00       .00       .00   1126.70   1590.00   1130.83       .00   1132.08     36.00      4.97    320.36    265.00
        58.000      7.00   1136.00   1135.00   1126.40   1590.00   1131.29       .00   1132.08     15.94      3.88    410.05    398.29
        59.000     20.00       .00       .00   1126.70   1590.00   1131.31       .00   1132.16     17.48      4.12    393.74    380.35
1
 11-27-90     12:49:48                                                                                                PAGE   38
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BOW RIVER

SUMMARY PRINTOUT TABLE  150

        SECNO       Q        CWSEL    DIFWSP    DIFWSX    DIFKWS    TOPWID     XLCH

        1.000   1960.00   1090.60       .00       .00       .00    296.01       .00
        2.000   1960.00   1091.21       .00       .61       .00    313.14    410.00
        3.000   1960.00   1091.61       .00       .40       .00    269.10    325.00
        4.000   1960.00   1093.27       .00      1.66       .00    264.19    720.00
        5.000   1960.00   1093.66       .00       .38       .00    315.51    185.00
        6.000   1960.00   1094.34       .00       .68       .00    309.09    530.00
        7.000   1960.00   1094.76       .00       .43       .00    130.76    530.00
        8.000   1960.00   1095.86       .00      1.10       .00    163.25    540.00
        9.000   1960.00   1097.27       .00      1.41       .00    157.19    380.00
       10.000   1950.00   1097.53       .00       .25       .00    279.65    400.00
       11.000   1950.00   1098.59       .00      1.06       .00    219.79    510.00
       12.000   1950.00   1098.90       .00       .31       .00    208.43    370.00
       13.000   1950.00   1099.62       .00       .72       .00    124.79    530.00
       14.000   1950.00   1100.60       .00       .99       .00    169.22    325.00
       15.000   1950.00   1100.94       .00       .33       .00    175.19    390.00
*      16.000   1950.00   1103.15       .00      2.21       .00    137.03    465.00
       17.000   1950.00   1104.90       .00      1.76       .00    241.79    650.00
       18.000   1950.00   1105.00       .00       .09       .00    195.06    510.00
       19.000   1950.00   1105.51       .00       .52       .00    136.22    510.00
       20.000   1940.00   1106.25       .00       .74       .00    206.53    440.00
       21.000   1940.00   1106.65       .00       .40       .00    139.74    430.00
       22.000   1940.00   1107.84       .00      1.19       .00    207.66    410.00
       23.000   1940.00   1108.14       .00       .30       .00    141.18    410.00
       24.000   1940.00   1108.91       .00       .77       .00    154.89    380.00
       25.000   1940.00   1110.22       .00      1.31       .00    168.89    575.00
       26.000   1940.00   1110.39       .00       .17       .00    267.71    295.00
       27.000   1940.00   1111.46       .00      1.08       .00    240.79    385.00
*      28.000   1940.00   1111.82       .00       .35       .00     91.31    585.00
       29.000   1940.00   1113.90       .00      2.09       .00    223.45    410.00
       30.000   1934.00   1114.13       .00       .22       .00    255.07    415.00
       31.000   1934.00   1114.02       .00      -.10       .00    115.46    350.00
       32.000   1934.00   1116.04       .00      2.02       .00    141.32    625.00
       33.000   1934.00   1116.45       .00       .41       .00    126.27    310.00
       34.000   1934.00   1117.31       .00       .86       .00    160.97    390.00
       35.000   1934.00   1118.10       .00       .78       .00    161.93    295.00
       36.000   1934.00   1118.14       .00       .05       .00    147.49     50.00
       37.100   1934.00   1118.11       .00      -.03       .00    142.29      1.00
       37.200   1934.00   1118.14       .00       .03       .00    142.30      8.00
       38.000   1934.00   1118.29       .00       .15       .00    143.88      1.00
       39.000   1934.00   1118.48       .00       .19       .00    171.56     40.00
       40.000   1934.00   1118.73       .00       .26       .00    153.74    330.00
       41.000   1934.00   1119.91       .00      1.17       .00    136.35    415.00
       42.000   1934.00   1119.77       .00      -.14       .00    123.06    305.00
       43.000   1934.00   1121.78       .00      2.01       .00    210.55    545.00
       44.000   1913.00   1122.07       .00       .29       .00    141.83    430.00
*      45.000   1913.00   1122.39       .00       .33       .00    118.88     85.00
*      47.000   1913.00   1123.06       .00       .66       .00    120.85     13.00
       48.000   1913.00   1123.60       .00       .54       .00    193.70    145.00
       49.000   1913.00   1124.11       .00       .51       .00    234.18    355.00
*      49.100   1913.00   1124.05       .00      -.07       .00    141.35    405.00
       50.000   1913.00   1125.95       .00      1.90       .00    420.38    335.00
       51.000   1590.00   1126.45       .00       .51       .00    179.48    505.00
       52.000   1590.00   1127.27       .00       .81       .00    151.53    540.00
       53.000   1590.00   1128.17       .00       .90       .00    125.15    425.00
       54.000   1590.00   1129.99       .00      1.82       .00    182.83    465.00
       55.000   1590.00   1130.65       .00       .66       .00    129.63    570.00
       56.000   1590.00   1130.83       .00       .18       .00    102.86    120.00
       58.000   1590.00   1131.29       .00       .46       .00    100.43      7.00
       59.000   1590.00   1131.31       .00       .01       .00    102.23     20.00
1
 11-27-90     12:49:48                                                                    PAGE   41


 SUMMARY OF ERRORS AND SPECIAL NOTES


CAUTION  SECNO=     16.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=     16.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=     28.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=     28.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=     45.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=     45.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=     47.000  PROFILE= 1  HYDRAULIC JUMP D.S.

CAUTION  SECNO=     49.100  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=     49.100  PROFILE= 1  MINIMUM SPECIFIC ENERGY

1
 11-27-90     12:52:29                                                                    PAGE    1



                                                             THIS RUN EXECUTED 11-27-90
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
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1*******************************************************                ****************************************
 *  WATER SURFACE PROFILES                              *                  *  U.S. ARMY CORPS OF ENGINEERS
 *
 *  VERSION OF NOVEMBER 1976                            *                  *  THE HYDROLOGIC ENGINEERING CENTER
 *
 *  UPDATED MAY 1984                                    *                  *  609 SECOND STREET, SUITE D
 *
 *  IBM-PC-XT VERSION AUGUST 1985                       *                  *  DAVIS, CALIFORNIA 95616
 *
 *  RUN DATE  11-27-90   TIME  13:47:30                   *                  *  (916) 440-2105 (FTS) 448-2105
  *
 *******************************************************                ****************************************




                                                    X     X  XXXXXXX   XXXXX           XXXXX
                                                    X     X  X        X     X         X     X
                                                    X     X  X        X                     X
                                                    XXXXXXX  XXXX     X         XXXXX   XXXXX
                                                    X     X  X        X                X
                                                    X     X  X        X     X          X
                                                    X     X  XXXXXXX   XXXXX           XXXXXXX
1
  11-27-90     13:47:31                                                                                          PAGE    1


                                                                                   THIS RUN EXECUTED 11-27-90
 ***************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ***************************************************


 T1 JUMPING POUND CREEK AT COCHRANE          FILE=COCHJP1        "FINAL"
 T2 1:100 YEAR Q=323 CMS                     CHANNEL  'N'=0.040
 T3                                          OVERBANK 'N'=0.100

 J1  ICHECK    INQ       NINV      IDIR       STRT      METRIC     HVINS      Q          WSEL      FQ

         0.        0.        0.        0.   .004000      1.00        .0      323.  1126.500      .000

 J2  NPROF     IPLOT     PRFVS     XSECV      XSECH     FN        ALLDC      IBW        CHNIM      ITRACE

      -1.000      .000      .000      .000      .000      .000    -1.000      .000      .000      .000

 J3  VARIABLE CODES FOR SUMMARY PRINTOUT

     150.000      .000      .000      .000      .000      .000      .000      .000      .000      .000

 J6  IHLEQ     ICOPY

       1.000      .000      .000      .000      .000      .000      .000      .000      .000      .000


 NC       .100       .100       .040       .100       .300       .000       .000       .000       .000       .000
 X1      1.000     18.000      8.000     44.700       .000       .000       .000       .000       .000       .000
 GR   1128.400       .000   1127.900       .600   1125.400      8.000   1123.600     12.800   1123.100     17.500
 GR   1123.100     23.700   1123.600     37.900   1124.200     44.700   1124.400     52.400   1124.200     68.600
 GR   1124.000     83.000   1124.200     92.900   1124.000    115.000   1123.500    120.000   1123.500    130.000
 GR   1124.000    135.000   1125.000    140.000   1126.000    145.000       .000       .000       .000       .000

 X1      2.000     28.000     92.700    137.400    280.000    230.000    260.000       .000       .000       .000
 GR   1133.100       .000   1132.800      2.400   1132.400      3.400   1132.400      6.200   1132.000     12.600
 GR   1131.400     23.400   1129.600     28.600   1126.600     34.200   1126.200     51.500   1126.400     65.300
 GR   1125.400     73.800   1126.400     78.100   1126.400     92.700   1124.400     95.800   1124.200    101.700
 GR   1124.900    111.400   1124.700    121.500   1124.600    129.300   1125.500    137.400   1125.900    145.600
 GR   1126.300    149.900   1126.300    158.400   1125.800    170.600   1125.400    176.200   1124.200    180.800
 GR   1124.200    183.700   1126.000    185.000   1127.000    190.000       .000       .000       .000       .000

 NC       .000       .000       .000       .300       .500       .000       .000       .000       .000       .000
 X1      4.000     27.000    180.000    222.530    235.000    255.000    260.000       .000       .000       .000
 X3     10.000       .000       .000       .000       .000       .000       .000   1129.600   1130.500       .000
 GR   1131.000       .000   1128.000     20.000   1128.000     40.000   1128.000     60.000   1128.000     80.000
 GR   1128.000    100.000   1128.000    120.000   1128.000    140.000   1128.000    160.000   1127.300    180.000
 GR   1127.300    180.010   1126.800    182.100   1125.800    185.400   1125.200    188.000   1125.300    191.400
 GR   1125.800    195.600   1125.400    200.800   1125.200    206.200   1125.700    208.800   1127.300    210.500
 GR   1127.300    222.520   1127.300    222.530   1129.000    223.500   1129.000    242.500   1129.000    262.500
 GR   1130.000    277.500   1131.000    282.500       .000       .000       .000       .000       .000       .000
1
  11-27-90     13:47:31                                                                                          PAGE    2


 X1      4.100       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
 X3     10.000       .000       .000       .000       .000       .000       .000   1129.600   1130.500       .000
 BT     27.000       .000   1133.100   1131.000     20.000   1131.900   1128.000     40.000   1130.800   1128.000
 BT     60.000   1130.100   1128.000     80.000   1129.500   1128.000    100.000   1129.200   1128.000    120.000
 BT   1129.000   1128.000    140.000   1128.900   1128.000    160.000   1129.000   1128.000    180.000   1129.400
 BT   1127.300    180.010   1129.400   1128.500    182.100   1129.400   1128.500    185.400   1129.500   1128.600
 BT    188.000   1129.600   1128.600    191.400   1129.600   1128.600    195.600   1129.700   1128.700    200.800
 BT   1129.800   1128.800    206.200   1129.900   1128.900    208.800   1130.000   1128.900    210.500   1130.000
 BT   1128.900    222.520   1130.300   1129.100    222.530   1130.300   1127.300    223.500   1130.300   1129.000
 BT    242.500   1131.500   1129.000    262.500   1132.000   1129.000    277.500   1132.400   1130.000    282.500
 BT   1132.600   1131.000       .000       .000       .000       .000       .000       .000       .000       .000

 X1      6.000     25.000    180.000    222.530      6.250      6.250      6.250       .000       .000       .000
 X3     10.000       .000       .000       .000       .000       .000       .000   1129.600   1130.500       .000
 BT     25.000       .000   1133.100   1133.000     20.000   1131.900   1131.000     40.000   1130.800   1129.000
 BT     60.000   1130.100   1128.000     80.000   1129.500   1128.000    100.000   1129.200   1128.000    120.000
 BT   1129.000   1128.000    140.000   1128.900   1128.000    160.000   1129.000   1128.000    180.000   1129.400
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BT   1127.300    180.010   1129.400   1128.500    186.600   1129.600   1128.600    188.100   1129.600   1128.600
BT    192.500   1129.700   1128.700    198.100   1129.800   1128.800    204.700   1129.900   1128.900    212.300
BT   1130.100   1129.000    213.500   1130.100   1129.000    215.600   1130.200   1129.000    222.520   1130.300
BT   1129.100    222.530   1130.300   1127.300    223.500   1130.300   1129.000    242.500   1131.500   1130.000
BT    262.500   1132.000   1131.000    282.500   1132.600   1132.600       .000       .000       .000       .000
GR   1133.000       .000   1131.000     20.000   1129.000     40.000   1128.000     60.000   1128.000     80.000
GR   1128.000    100.000   1128.000    120.000   1128.000    140.000   1128.000    160.000   1127.300    180.000
GR   1127.300    180.010   1125.600    186.600   1125.300    188.100   1125.400    192.500   1125.900    198.100
GR   1125.600    204.700   1125.400    212.300   1125.700    213.500   1127.300    215.600   1127.300    222.520
GR   1127.300    222.530   1129.000    223.500   1130.000    242.500   1131.000    262.500   1132.600    282.500

X1      6.100       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1129.600   1130.500       .000

X1      7.100     14.000    180.000    205.000    150.000    130.000    140.000       .000       .000       .000
GR   1135.000       .000   1133.000      5.000   1132.000     15.000   1131.000     30.000   1130.000     75.000
GR   1129.000    150.000   1128.000    155.000   1127.000    160.000   1127.000    180.000   1125.800    185.000
GR   1125.800    200.000   1128.000    205.000   1130.000    210.000   1135.000    215.000       .000       .000

NC       .000       .000       .000       .100       .300       .000       .000       .000       .000       .000
X1      8.000     23.000    165.000    209.300    230.000    375.000    260.000       .000       .000       .000
GR   1134.600       .000   1131.800      9.400   1130.500     21.100   1131.200     41.300   1131.400     58.700
GR   1131.300     62.400   1130.500     65.300   1129.600     73.900   1130.200     84.800   1130.800    111.500
GR   1130.800    114.900   1130.700    142.800   1130.900    165.000   1129.500    175.700   1129.100    177.700
GR   1128.200    180.000   1127.700    188.300   1127.200    194.100   1126.900    198.300   1127.300    200.700
GR   1127.800    202.000   1129.200    204.900   1132.900    209.300       .000       .000       .000       .000

X1      9.000     22.000     78.100    111.600    250.000    270.000    260.000       .000       .000       .000
GR   1145.400       .000   1140.700     10.100   1139.500     11.500   1136.200     17.000   1132.700     24.900
GR   1131.800     30.600   1131.700     35.200   1131.200     37.600   1131.200     53.100   1131.100     58.700
GR   1130.500     60.700   1131.200     64.300   1129.300     69.000   1129.500     70.700   1129.100     78.100
GR   1127.100     82.000   1126.800     83.300   1126.800     86.800   1127.800     93.900   1126.600     99.900
GR   1127.200    102.100   1133.700    111.600       .000       .000       .000       .000       .000       .000
1
  11-27-90    13:47:31                                                                                PAGE    3


X1     10.000     11.000     25.500     67.400    370.000    370.000    370.000       .000       .000       .000
GR   1138.400       .000   1132.000      9.700   1132.200     25.500   1131.500     34.100   1130.800     36.500
GR   1129.900     43.100   1130.700     52.100   1131.900     67.400   1132.500     83.500   1133.400    100.700
GR   1133.900    116.800       .000       .000       .000       .000       .000       .000       .000       .000

X1     11.000     18.000      4.600     53.700    400.000    430.000    410.000       .000       .000       .000
GR   1142.200       .000   1140.300      3.100   1137.800      4.600   1133.900      9.300   1133.600     10.400
GR   1133.300     20.700   1133.900     24.100   1134.300     38.300   1134.700     47.200   1135.600     49.500
GR   1135.900     53.700   1135.700     67.200   1136.200     95.400   1136.400    128.300   1135.900    134.300
GR   1136.300    140.700   1137.200    144.100   1137.200    145.100       .000       .000       .000       .000

X1     12.000     27.000      8.900     73.100    245.000    160.000    215.000       .000       .000       .000
GR   1142.300       .000   1141.800       .020   1138.300      8.900   1136.500     16.500   1135.900     26.300
GR   1135.600     29.500   1135.500     31.200   1135.500     34.800   1135.700     40.200   1135.600     45.000
GR   1135.300     50.600   1135.100     61.500   1135.500     69.300   1137.000     73.100   1137.200     98.600
GR   1137.500    134.300   1137.200    150.300   1136.800    154.900   1136.800    159.200   1137.100    167.600
GR   1136.600    182.800   1137.000    186.700   1136.900    190.700   1137.400    194.300   1137.400    201.900
GR   1138.200    208.100   1138.100    224.500       .000       .000       .000       .000       .000       .000

X1     13.000     22.000    108.000    139.300    260.000    195.000    230.000       .000       .000       .000
GR   1146.700       .000   1143.500     13.500   1141.300     37.200   1140.000     43.500   1139.600     58.500
GR   1138.900     62.500   1138.600     79.800   1137.700     93.300   1137.600     93.800   1137.500    108.000
GR   1135.700    111.000   1135.400    114.100   1135.200    120.800   1135.300    132.800   1135.500    135.700
GR   1136.500    138.700   1137.400    139.300   1137.600    144.700   1138.800    150.400   1139.100    155.200
GR   1143.200    169.400   1142.700    221.200       .000       .000       .000       .000       .000       .000

X1     14.000     19.000      2.200     62.800    420.000    435.000    430.000       .000       .000       .000
GR   1145.300       .000   1143.800      2.200   1139.300      8.200   1138.700      9.600   1138.700     15.600
GR   1139.100     22.500   1139.300     24.400   1139.600     31.700   1139.400     39.800   1139.000     44.900
GR   1139.400     45.900   1139.700     47.700   1140.800     49.400   1141.600     62.800   1141.700     76.000
GR   1141.900     89.900   1142.000    111.300   1155.000    132.500   1162.400    149.500       .000       .000

X1     15.000     16.000     34.600     83.000    285.000    225.000    245.000       .940       .000       .000
GR   1147.500       .000   1144.800      8.000   1143.100     34.600   1143.000     35.300   1141.700     41.600
GR   1141.100     61.300   1140.800     69.700   1140.500     74.900   1141.000     79.900   1142.300     83.000
GR   1142.500    104.700   1142.400    115.300   1142.600    121.300   1142.300    136.300   1154.400    166.100
GR   1162.400    213.400       .000       .000       .000       .000       .000       .000       .000       .000

X1     16.000     21.000     90.800    142.100    240.000    110.000    180.000       .000       .000       .000
GR   1151.200       .000   1148.600     54.700   1145.300     78.600   1144.800     90.800   1143.700     91.200
GR   1141.900     94.700   1141.800     95.600   1141.900    101.600   1141.900    110.300   1142.200    112.800
GR   1142.900    114.300   1143.200    126.200   1142.600    129.500   1142.500    133.200   1142.500    137.100
GR   1143.400    142.100   1143.300    157.700   1142.200    165.600   1146.700    172.500   1153.100    184.200
GR   1162.400    204.200       .000       .000       .000       .000       .000       .000       .000       .000

X1     17.000     24.000    130.600    169.600    260.000    340.000    305.000       .000       .000       .000
GR   1151.200       .000   1146.600     11.400   1146.500     36.700   1145.400     46.400   1146.600     65.000
GR   1145.800     81.200   1145.900     94.400   1146.200    104.000   1146.200    118.500   1146.800    130.600
GR   1146.200    132.900   1145.100    134.200   1144.900    135.000   1144.500    138.500   1144.400    140.800
GR   1144.800    144.600   1144.600    156.500   1144.400    161.400   1144.700    163.200   1145.200    165.100
GR   1146.200    166.200   1147.100    169.600   1149.800    172.500   1150.900    173.800       .000       .000
1
  11-27-90    13:47:31                                                                                PAGE    4


X1     18.000     18.000     43.000     81.800    315.000    370.000    345.000       .000       .000       .000
GR   1152.900       .000   1149.400     10.700   1148.900     14.800   1149.100     25.400   1147.600     33.500
GR   1147.200     43.000   1146.600     44.400   1146.200     48.900   1145.800     55.000   1146.000     59.800
GR   1145.500     69.300   1145.600     76.200   1146.100     77.700   1149.000     81.800   1148.600    100.300
GR   1148.500    117.200   1154.300    127.300   1166.000    144.400       .000       .000       .000       .000

X1     19.000     20.000      8.300     46.400    275.000    255.000    270.000       .000       .000       .000
GR   1154.900       .000   1152.600      2.900   1151.700      4.300   1149.800      8.300   1147.200     13.200
GR   1146.900     16.300   1146.600     18.400   1146.500     23.100   1146.900     27.600   1147.200     30.100
GR   1147.800     34.700   1147.700     41.600   1148.200     44.800   1149.100     46.400   1149.100     49.800
GR   1149.800     62.600   1150.500     88.400   1150.000    107.000   1151.300    114.300   1153.700    118.200

X1     20.000     17.000     67.500    103.100    360.000    310.000    330.000       .000       .000       .000
GR   1156.200       .000   1155.700      3.600   1154.600      7.100   1153.700     21.500   1152.600     35.200
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GR   1151.100     56.200  1150.900     67.500   1148.900     74.500   1148.400     78.900   1148.300     81.100
GR   1148.500     87.400  1148.500     91.900   1148.900     94.000   1149.500     96.400   1155.000    103.100
GR   1161.100    111.000  1161.100    111.800       .000       .000       .000       .000       .000       .000

X1     21.000     15.000   212.300    251.900    250.000    340.000    300.000       .000       .000       .000
GR   1156.200       .000  1156.100     90.800   1155.600    104.300   1156.100    115.300   1155.800    163.300
GR   1155.000    197.600  1153.800    202.200   1153.400    212.300   1152.100    213.900   1151.700    216.500
GR   1151.700    219.000  1151.300    228.800   1151.200    238.300   1151.700    241.200   1158.700    251.900
EJ       .000       .000      .000       .000       .000       .000       .000       .000       .000       .000
1
  11-27-90     13:47:31                                                                                     PAGE     5


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *PROF 1

 IHLEQ = 1.  THEREFORE FRICTION LOSS (HL) IS CALCULATED AS A FUNCTION OF
 PROFILE TYPE, WHICH CAN VARY FROM REACH TO REACH.  SEE DOCUMENTATION FOR
 DETAILS.

 CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

 CCHV=    .100 CEHV=    .300
 *SECNO 1.000
      1.00      2.53  1125.63  1125.04  1126.50  1125.84      .22       .00       .00  1125.40
      323.        0.     194.     129.       0.      76.     149.        0.        0.   1124.20
       .00       .01     2.56      .86     .100     .040     .100      .000  1123.10      7.32
   .004026        0.       0.       0.        0       11        5       .00   135.83   143.15
0
 *SECNO 2.000
      2.00      2.54  1126.74  1126.42      .00  1127.12      .38      1.23       .05  1126.40
      323.       14.     267.      43.      27.      89.      49.       48.       36.   1125.50
       .03       .50     3.00      .87     .100     .040     .100      .000  1124.20     33.96
   .005867      280.     260.     230.        1       11        0       .00   154.69   188.65
0
 CCHV=    .300 CEHV=    .500
 *SECNO 4.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1129.60 ELREA=     1130.50

      4.00      3.11  1128.31  1127.95      .00  1128.95      .63      1.70       .12  1127.30
      323.        0.     323.       0.       0.      92.       0.       81.       61.   1127.30
       .05       .00     3.52      .00     .100     .040     .100      .000  1125.20    180.00
   .007331      235.     260.     255.        3        8        0       .00    42.53   222.53
0
 *SECNO 4.100

 3370 NORMAL BRIDGE,NRD= 27 MIN ELTRD= 1128.90 MAX ELLC= 1131.00


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1129.60 ELREA=     1130.50

      4.10      3.13  1128.33  1127.94      .00  1128.95      .63       .01       .00  1127.30
      323.        0.     323.       0.       0.      92.       0.       81.       61.   1127.30
       .05       .00     3.51      .00     .100     .040     .100      .000  1125.20    180.00
   .007255        1.       1.       1.        0       12        0      -.30    42.53   222.53
0
1
  11-27-90     13:47:31                                                                                     PAGE     6


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *SECNO 6.000

 3370 NORMAL BRIDGE,NRD= 25 MIN ELTRD= 1128.90 MAX ELLC= 1133.00


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1129.60 ELREA=     1130.50

      6.00      3.29  1128.59  1127.82      .00  1129.04      .45       .04       .05  1127.30
      323.        0.     323.       0.       0.     108.       0.       82.       61.   1127.30
       .05       .00     2.98      .00     .100     .040     .100      .000  1125.30    180.00
   .004959        6.       6.       6.        3       18        0      -.74    42.53   222.53
0
 *SECNO 6.100

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1129.60 ELREA=     1130.50

      6.10      3.30  1128.60  1127.83      .00  1129.05      .45       .00       .00  1127.30
      323.        0.     323.       0.       0.     109.       0.       82.       61.   1127.30
       .05       .00     2.96      .00     .100     .040     .100      .000  1125.30    180.00
   .004102        1.       1.       1.        0       15        0       .00    42.53   222.53
0
 *SECNO 7.100
      7.10      3.38  1129.18  1128.50      .00  1129.69      .51       .61       .03  1127.00
      323.       59.     263.       1.      57.      76.       2.       99.       69.   1128.00
       .06      1.04     3.47      .45     .100     .040     .100      .000  1125.80    136.66
   .004513      150.     140.     130.        2       15        0       .00    71.28   207.94
0
 CCHV=    .100 CEHV=    .300
 *SECNO 8.000

 3265 DIVIDED FLOW

      8.00      3.69  1130.59  1130.29      .00  1131.25      .66      1.52       .04  1130.90
      323.        9.     314.       0.      16.      86.       0.      129.       88.   1132.90
       .08       .57     3.64      .00     .100     .040     .100      .000  1126.90     20.27
   .007747      230.     260.     375.        2        5        0       .00    80.03   206.56
```

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0
 *SECNO 9.000
      9.00     5.12  1131.72  1129.88      .00  1132.01      .29      .72      .04  1129.10
      323.      24.     299.       0.      45.     121.       0.     164.     108.   1133.70
       .11      .54     2.46      .00     .100     .040     .100     .000  1126.60    34.57
   .001690     250.     260.     270.        2       11        0      .00    74.13   108.70
0
1
  11-27-90     13:47:31                                                                                            PAGE    7

    SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
    Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
    TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
    SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


 *SECNO 10.000
     10.00     3.23  1133.13  1132.86      .00  1133.66      .53     1.58      .07  1132.20
      323.      14.     295.      13.      17.      88.      19.     217.     138.   1131.90
       .14      .83     3.37      .71     .100     .040     .100     .000  1129.90     7.98
   .006855     370.     370.     370.        3       14        0      .00    87.59    95.57
0
 *SECNO 11.000

 3265 DIVIDED FLOW

     11.00     2.88  1136.18  1135.97      .00  1136.79      .61     3.11      .02  1137.80
      323.       0.     318.       5.       0.      91.      13.     264.     176.   1135.90
       .18      .00     3.48      .39     .100     .040     .100     .000  1133.30     6.55
   .008283     400.     410.     430.        3       11        0      .00    95.53   138.77
0
 *SECNO 12.000
     12.00     2.59  1137.69  1137.19      .00  1137.96      .28     1.14      .03  1138.30
      323.       0.     292.      31.       0.     120.      69.     293.     202.   1137.00
       .20      .00     2.44      .45     .100     .040     .100     .000  1135.10    11.51
   .003972     245.     215.     160.        1       15        0      .00   192.58   204.09
0
 *SECNO 13.000
     13.00     3.26  1138.46  1137.84      .00  1139.02      .55      .97      .08  1137.50
      323.      10.     309.       4.      18.      92.       7.     327.     230.   1137.40
       .22      .57     3.37      .59     .100     .040     .100     .000  1135.20    81.80
   .004549     260.     230.     195.        2        5        0      .00    67.02   148.82
0
 *SECNO 14.000
     14.00     2.69  1141.39  1141.10      .00  1141.99      .60     2.95      .01  1143.80
      323.       0.     323.       0.       0.      94.       0.     373.     255.   1141.60
       .26      .00     3.43      .00     .100     .040     .100     .000  1138.70     5.43
   .009196     420.     430.     435.        2       15        0      .00    53.67    59.09
0
 *SECNO 15.000
     15.00     2.86  1143.36  1143.07      .00  1143.80      .44     1.80      .02  1143.10
      323.       0.     288.      35.       1.      92.      48.     401.     274.   1142.30
       .28      .20     3.12      .74     .100     .040     .100     .000  1140.50    28.67
   .006174     285.     245.     225.        2       11        0      .00   101.91   130.58
0
1
  11-27-90     13:47:31                                                                                            PAGE    8

    SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
    Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
    TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
    SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


 *SECNO 16.000
     16.00     2.65  1144.45  1144.03      .00  1144.85      .40     1.05      .00  1144.80
      323.       0.     291.      32.       0.      99.      35.     423.     288.   1143.40
       .30      .00     2.95      .92     .100     .040     .100     .000  1141.80    90.93
   .005958     240.     180.     110.        2       15        0      .00    78.13   169.05
0
 *SECNO 17.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     17.00     2.46  1146.86  1146.86      .00  1147.40      .54     2.72     -.42  1146.80
      323.      61.     262.       0.      79.      73.       0.     465.     321.   1147.10
       .33      .78     3.59      .00     .100     .040     .100     .000  1144.40    10.74
   .009010     260.     305.     340.        0       12        0      .00   157.97   168.71
0
 *SECNO 18.000

 3265 DIVIDED FLOW

     18.00     3.30  1148.80  1147.98      .00  1149.22      .42     1.81      .01  1147.20
      323.      12.     310.       1.      17.     105.       5.     512.     361.   1149.00
       .36      .69     2.94      .22     .100     .040     .100     .000  1145.50    27.02
   .003751     315.     345.     370.        3        5        0      .00    81.17   117.72
0
 *SECNO 19.000
     19.00     3.43  1149.93  1149.38      .00  1150.49      .57     1.23      .04  1149.80
      323.       0.     318.       5.       0.      95.       9.     543.     380.   1149.10
       .38      .01     3.36      .51     .100     .040     .100     .000  1146.50     8.03
   .005535     275.     270.     255.        3       11        0      .00    59.37    67.40
0
 *SECNO 20.000
     20.00     3.46  1151.76  1151.28      .00  1152.44      .68     1.91      .03  1150.90
      323.       7.     316.       0.      12.      86.       0.     576.     398.   1155.00
       .41      .58     3.69      .00     .100     .040     .100     .000  1148.30    46.94
   .006062     360.     330.     310.        2       11        0      .00    52.21    99.15
0
 *SECNO 21.000
     21.00     2.79  1153.99  1153.87      .00  1154.91      .92     2.40      .07  1153.40
      323.       2.     321.       0.       4.      75.       0.     603.     412.   1158.70
       .43      .53     4.27      .00     .100     .040     .100     .000  1151.20   201.44
   .009966     250.     300.     340.        2       15        0      .00    43.27   244.71
0
1
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PROFILE FOR STREAM


PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA


ELEVATION  1120.     1125.     1130.     1135.     1140.     1145.     1150.     1155.     1160.     1165.
    SECNO   CUMDIS

     1.00     0.  .     I R CWE       .         .         .         .         .         .         .         .
                50.  .      I R.CE       .         .         .         .         .         .         .         .
               100.  .      I R.CWE      .         .         .         .         .         .         .         .
               150.  .      I  R CE      .         .         .         .         .         .         .         .
               200.  .       I R CWE     .         .         .         .         .         .         .         .
               250.  .       I .R WE     .         .         .         .         .         .         .         .
     2.00   300.  .       I .R WE     .         .         .         .         .         .         .         .
               350.  .        I. RCWEM   .         .         .         .         .         .         .         .
               400.  .        I. RLCWEM  .         .         .         .         .         .         .         .
               450.  .         I  RLWE  M.         .         .         .         .         .         .         .
               500.  .         I   LCWE  M         .         .         .         .         .         .         .
     4.00   550.  .         I    LCWE . M       .         .         .         .         .         .         .
     4.10   600.  .         I    LCWE . M       .         .         .         .         .         .         .
     6.00   650.  .         .I   LCWE .    M    .         .         .         .         .         .         .
     6.10   700.  .         .I   LCWE .    M    .         .         .         .         .         .         .
     7.10   750.  .         . I L RCWE.         M         .         .         .         .         .         .
               800.  .         . I   L CWE        M.         .         .         .         .         .         .
               850.  .         . I    LCWRE      M .         .         .         .         .         .         .
               900.  .         .  I     CWER     M .         .         .         .         .         .         .
     8.00   950.  .         .   I     .WLE  R   .         .         .         .         .         .         .
              1000.  .         .   I     CLWE  R   .         .         .         .         .         .         .
              1050.  .         .   I     C WE  R   .         .         .         .         .         .         .
              1100.  .         .  I      C WE   R  .         .         .         .         .         .         .
              1150.  .         .  I     LC  WE  R  .         .         .         .         .         .         .
     9.00  1200.  .         .  I    L C  WE  R  .         .         .         .         .         .         .
              1250.  .         .   I    L.C  E  R  .         .         .         .         .         .         .
              1300.  .         .    I    LC  WER M .         .         .         .         .         .         .
              1350.  .         .     I   .LC  ER M .         .         .         .         .         .         .
              1400.  .         .      I  . LC WE M .         .         .         .         .         .         .
              1450.  .         .       I . L CWE M .         .         .         .         .         .         .
              1500.  .         .        I.  LRCWEM .         .         .         .         .         .         .
              1550.  .         .        I.   LCWEM .         .         .         .         .         .         .
    10.00  1600.  .         .         I   L WEM .         .         .         .         .         .         .
              1650.  .         .         .I   RCWEM.         .         .         .         .         .         .
              1700.  .         .         .I    RCWE.         .         .         .         .         .         .
              1750.  .         .         . I    RW E         .         .         .         .         .         .
              1800.  .         .         .  I    RWEM        .         .         .         .         .         .
              1850.  .         .         .   I    RWEM       .         .         .         .         .         .
              1900.  .         .         .    I    CWEL      .         .         .         .         .         .
              1950.  .         .         .     I   .W EL     .         .         .         .         .         .
    11.00  2000.  .         .         .      I  . W E L   .         .         .         .         .         .
              2050.  .         .         .      I  . RWEML   .         .         .         .         .         .
              2100.  .         .         .       I .  CWEL   .         .         .         .         .         .
              2150.  .         .         .        I.  RWEL   .         .         .         .         .         .
    12.00  2200.  .         .         .         I   CWEL  .         .         .         .         .         .
              2250.  .         .         .         I   RCE M .         .         .         .         .         .
              2300.  .         .         .         I   RCWE  M         .         .         .         .         .
              2350.  .         .         .         I    CWE  . M       .         .         .         .         .
              2400.  .         .         .         I    LCWE .   M     .         .         .         .         .
    13.00  2450.  .         .         .         I    LCWE .    M    .         .         .         .         .
              2500.  .         .         .         .I    C WE.     M   .         .         .         .         .
              2550.  .         .         .         . I    CWE.      M  .         .         .         .         .
              2600.  .         .         .         .  I    CWE       M  .         .         .         .         .
              2650.  .         .         .         .   I    CWE      M .         .         .         .         .
              2700.  .         .         .         .   I    CWEL     M .         .         .         .         .
              2750.  .         .         .         .    I    CWE L    M.         .         .         .         .
              2800.  .         .         .         .     I   .CWE L    M         .         .         .         .
    14.00  2850.  .         .         .         .      I  . CWE   L .M        .         .         .         .
              2900.  .         .         .         .       I .  CWE L  .M        .         .         .         .
              2950.  .         .         .         .        I.   WE L  . M       .         .         .         .
              3000.  .         .         .         .         I   RWEL  .  M      .         .         .         .
              3050.  .         .         .         .         I   RCWE  .   M     .         .         .         .
    15.00  3100.  .         .         .         .         .I   RCWE .    M    .         .         .         .
              3150.  .         .         .         .         . I  R WE .      M  .         .         .         .
              3200.  .         .         .         .         . I   RCWE.        M.         .         .         .
              3250.  .         .         .         .         .  I  R CE.         .M        .         .         .
    16.00  3300.  .         .         .         .         .   I  RCWE         . M       .         .         .
              3350.  .         .         .         .         .   I   RCWE        . M       .         .         .
              3400.  .         .         .         .         .    I   RWE        . M       .         .         .
              3450.  .         .         .         .         .     I   RWE       . M       .         .         .
              3500.  .         .         .         .         .      I  . WE      . M       .         .         .
              3550.  .         .         .         .         .       I .  WE     . M       .         .         .
    17.00  3600.  .         .         .         .         .        I.   WE    . M       .         .         .
              3650.  .         .         .         .         .        I.   WE    . M       .         .         .
              3700.  .         .         .         .         .        I.   CWE   .  M      .         .         .
              3750.  .         .         .         .         .         I   LWE   .   M     .         .         .
              3800.  .         .         .         .         .         I   LCWE  .   M     .         .         .
              3850.  .         .         .         .         .         I   LC E  .    M    .         .         .
              3900.  .         .         .         .         .         .I  L CWE .    M    .         .         .
    18.00  3950.  .         .         .         .         .         .I  L C E .     M   .         .         .
              4000.  .         .         .         .         .         .I   LC WE.     M   .         .         .
              4050.  .         .         .         .         .         . I   LCWE.     M   .         .         .
              4100.  .         .         .         .         .         . I    LCWE      M  .         .         .
              4150.  .         .         .         .         .         . I     CWE      M  .         .         .
    19.00  4200.  .         .         .         .         .         .  I    RCWE     M  .         .         .
              4250.  .         .         .         .         .         .   I    CW E     M .         .         .
              4300.  .         .         .         .         .         .   I     CWE      M.         .         .
              4350.  .         .         .         .         .         .    I    CLWER     M         .         .
              4400.  .         .         .         .         .         .    I    .CWE R    M         .         .
              4450.  .         .         .         .         .         .     I   .LCWE  R  .M        .         .
              4500.  .         .         .         .         .         .     I   . CW E   R. M       .         .
    20.00  4550.  .         .         .         .         .         .      I  . LCWE    R M       .         .
              4600.  .         .         .         .         .         .       I .  CW E   .RM       .         .
              4650.  .         .         .         .         .         .        I.  LCW E  . R       .         .
              4700.  .         .         .         .         .         .         I   LCWE  . M R     .         .
              4750.  .         .         .         .         .         .         I    LCWE . M  R    .         .
              4800.  .         .         .         .         .         .         .I    LW E. M   R   .         .
    21.00  4850.  .         .         .         .         .         .         . I    LW E M    R  .         .
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1
  11-27-90     13:47:31                                                                                           PAGE    9



                                                                                  THIS RUN EXECUTED 11-27-90
 ****************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ****************************************************


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST



 SUMMARY PRINTOUT TABLE  150

       SECNO     XLCH     ELTRD     ELLC     ELMIN       Q      CWSEL     CRIWS      EG      10K*S      VCH      AREA     .01K

        1.000      .00      .00       .00  1123.10   323.00   1125.63   1125.04   1125.84   40.26     2.56   225.49    50.90
        2.000   260.00      .00       .00  1124.20   323.00   1126.74   1126.42   1127.12   58.67     3.00   165.13    42.17
        4.000   260.00      .00       .00  1125.20   323.00   1128.31   1127.95   1128.95   73.31     3.52    91.78    37.73
        4.100     1.00  1128.90   1131.00  1125.20   323.00   1128.33   1127.94   1128.95   72.55     3.51    92.07    37.92
        6.000     6.25  1128.90   1133.00  1125.30   323.00   1128.59   1127.82   1129.04   49.59     2.98   108.49    45.87
        6.100     1.00      .00       .00  1125.30   323.00   1128.60   1127.83   1129.05   41.02     2.96   109.09    50.43
        7.100   140.00      .00       .00  1125.80   323.00   1129.18   1128.50   1129.69   45.13     3.47   134.20    48.08
        8.000   260.00      .00       .00  1126.90   323.00   1130.59   1130.29   1131.25   77.47     3.64   102.05    36.70
        9.000   260.00      .00       .00  1126.60   323.00   1131.72   1129.88   1132.01   16.90     2.46   166.74    78.57
       10.000   370.00      .00       .00  1129.90   323.00   1133.13   1132.86   1133.66   68.55     3.37   123.72    39.01
       11.000   410.00      .00       .00  1133.30   323.00   1136.18   1135.97   1136.79   82.83     3.48   104.05    35.49
       12.000   215.00      .00       .00  1135.10   323.00   1137.69   1137.19   1137.96   39.72     2.44   188.31    51.25
       13.000   230.00      .00       .00  1135.20   323.00   1138.46   1137.84   1139.02   45.49     3.37   116.52    47.89
       14.000   430.00      .00       .00  1138.70   323.00   1141.39   1141.10   1141.99   91.96     3.43    94.13    33.68
       15.000   245.00      .00       .00  1140.50   323.00   1143.36   1143.07   1143.80   61.74     3.12   140.36    41.11
       16.000   180.00      .00       .00  1141.80   323.00   1144.45   1144.03   1144.85   59.58     2.95   133.43    41.84
 *     17.000   305.00      .00       .00  1144.40   323.00   1146.86   1146.86   1147.40   90.10     3.59   151.96    34.03
       18.000   345.00      .00       .00  1145.50   323.00   1148.80   1147.98   1149.22   37.51     2.94   127.86    52.74
       19.000   270.00      .00       .00  1146.50   323.00   1149.93   1149.38   1150.49   55.35     3.36   104.14    43.41
       20.000   330.00      .00       .00  1148.30   323.00   1151.76   1151.28   1152.44   60.62     3.69    97.43    41.48
       21.000   300.00      .00       .00  1151.20   323.00   1153.99   1153.87   1154.91   99.66     4.27    79.28    32.36
1
  11-27-90     13:47:31                                                                                           PAGE   11



 SUMMARY PRINTOUT TABLE  150

       SECNO       Q       CWSEL     DIFWSP     DIFWSX     DIFKWS     TOPWID      XLCH

        1.000   323.00   1125.63       .00        .00       -.87     135.83       .00
        2.000   323.00   1126.74       .00       1.11        .00     154.69    260.00
        4.000   323.00   1128.31       .00       1.58        .00      42.53    260.00
        4.100   323.00   1128.33       .00        .01        .00      42.53      1.00
        6.000   323.00   1128.59       .00        .26        .00      42.53      6.25
        6.100   323.00   1128.60       .00        .01        .00      42.53      1.00
        7.100   323.00   1129.18       .00        .57        .00      71.28    140.00
        8.000   323.00   1130.59       .00       1.42        .00      80.03    260.00
        9.000   323.00   1131.72       .00       1.13        .00      74.13    260.00
       10.000   323.00   1133.13       .00       1.41        .00      87.59    370.00
       11.000   323.00   1136.18       .00       3.05        .00      95.53    410.00
       12.000   323.00   1137.69       .00       1.50        .00     192.58    215.00
       13.000   323.00   1138.46       .00        .78        .00      67.02    230.00
       14.000   323.00   1141.39       .00       2.92        .00      53.67    430.00
       15.000   323.00   1143.36       .00       1.97        .00     101.91    245.00
       16.000   323.00   1144.45       .00       1.09        .00      78.13    180.00
 *     17.000   323.00   1146.86       .00       2.41        .00     157.97    305.00
       18.000   323.00   1148.80       .00       1.93        .00      81.17    345.00
       19.000   323.00   1149.93       .00       1.13        .00      59.37    270.00
       20.000   323.00   1151.76       .00       1.83        .00      52.21    330.00
       21.000   323.00   1153.99       .00       2.23        .00      43.27    300.00

1
  11-27-90     13:47:31                                                                                           PAGE   12



  SUMMARY OF ERRORS AND SPECIAL NOTES


 CAUTION  SECNO=     17.000   PROFILE= 1   CRITICAL DEPTH ASSUMED
 CAUTION  SECNO=     17.000   PROFILE= 1   MINIMUM SPECIFIC ENERGY

1
  11-27-90     13:48:19                                                                                           PAGE    1



                                                                                  THIS RUN EXECUTED 11-27-90
 ****************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ****************************************************
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1*****************************************************************                    ***********************************************
 *  WATER SURFACE PROFILES                                        *                      *  U.S. ARMY CORPS OF ENGINEERS
*
 *  VERSION OF NOVEMBER 1976                                      *                      *  THE HYDROLOGIC ENGINEERING CENTER
*
 *  UPDATED MAY 1984                                              *                      *  609 SECOND STREET, SUITE D
*
 *  IBM-PC-XT VERSION AUGUST 1985                                 *                      *  DAVIS, CALIFORNIA 95616
*
 *  RUN DATE  11-27-90    TIME  13:28:45                            *                      *  (916) 440-2105 (FTS) 448-2105
  *
 *****************************************************************                    ***********************************************



                                   X     X  XXXXXXX   XXXXX           XXXXX
                                   X     X  X        X     X         X     X
                                   X     X  X        X                     X
                                   XXXXXXX  XXXX     X         XXXXX  XXXXX
                                   X     X  X        X               X
                                   X     X  X        X     X         X
                                   X     X  XXXXXXX   XXXXX          XXXXXXX
1
  11-27-90     13:28:46                                                                                          PAGE    1



                                                                             THIS RUN EXECUTED 11-27-90
 **************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 **************************************************


T1 BIGHILL CREEK AT COCHRANE        (FILENAME=COCHBH1)          "FINAL"
T2 1:100 YEAR Q=21 CMS
T3       BIGHILL CREEK              CHANNEL'N'=0.07

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0.        0.        0.        0.   .000000      1.00        .0       21.  1122.000      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

     -1.000      .000    -1.000      .000      .000    -1.000    -1.000      .000      .000      .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    150.000      .000      .000      .000      .000      .000      .000      .000      .000      .000


NC       .100      .100      .070      .100      .300      .000      .000      .000      .000      .000
X1     27.000    22.000    98.600   108.600      .000      .000      .000      .000      .000      .000
GR   1127.300      .000  1126.200    18.300  1125.600    26.700  1124.500    44.700  1123.600    60.900
GR   1123.400    74.400  1121.400    80.700  1120.700    98.600  1119.500   102.700  1119.500   103.000
GR   1119.400   104.400  1119.500   105.700  1120.200   108.600  1120.800   125.300  1120.600   137.500
GR   1121.800   141.600  1122.000   143.600  1122.100   155.200  1123.400   158.300  1125.100   161.100
GR   1128.200   167.300  1128.600   173.600      .000      .000      .000      .000      .000      .000

X1     26.000    19.000     9.400    19.200   140.000   140.000   140.000      .000      .000      .000
GR   1130.200      .000  1122.800     9.400  1121.200    12.500  1121.400    14.000  1121.600    16.500
GR   1122.000    19.200  1122.200    23.900  1121.800    25.400  1121.800    27.600  1122.400    29.800
GR   1122.600    37.800  1123.000    38.800  1123.000    55.600  1124.400    60.900  1124.900    72.100
GR   1126.600    82.800  1127.300    95.200  1128.300   126.000  1129.400   151.900      .000      .000

NC       .000      .000      .000      .300      .500      .000      .000      .000      .000      .000
X1     25.000    12.000    94.900   100.100   120.000   120.000   120.000      .000      .000      .000
X3     10.000      .000      .000      .000      .000      .000      .000  1130.000  1129.800      .000
GR   1124.600    90.700  1124.700    94.900  1123.600    95.100  1122.800    95.600  1122.400    96.200
GR   1122.200    97.000  1122.200    98.000  1122.400    98.600  1122.800    99.200  1123.600    99.800
GR   1124.700   100.100  1124.600   105.500      .000      .000      .000      .000      .000      .000

NC       .000      .000      .030      .000      .000      .000      .000      .000      .000      .000
X1     24.200      .000      .000      .000     1.000     1.000     1.000      .000      .000      .000
BT     12.000    90.700  1130.100  1124.600    94.900  1130.000  1124.700    95.100  1130.000  1125.600
BT     95.600  1129.900  1126.600    96.200  1129.900  1127.000    97.000  1129.800  1127.300    98.000
BT   1129.800  1127.300    98.600  1129.800  1127.000    99.200  1129.800  1126.600    99.800  1129.800
BT   1125.600   100.100  1129.800  1124.700   105.500  1129.500  1124.600      .000      .000      .000
1
  11-27-90     13:28:46                                                                                          PAGE    2



X1     24.100    10.000    54.500    59.700    37.200    37.200    37.200      .000      .000      .000
BT     10.000    50.100  1130.200  1125.900    54.500  1130.000  1125.100    54.700  1130.000  1126.300
BT     55.500  1129.900  1127.200    56.200  1129.900  1127.600    58.000  1129.800  1127.600    58.600
BT   1129.800  1127.200    59.400  1129.800  1126.300    59.700  1129.800  1125.100    61.900  1129.600
BT   1125.100      .000      .000      .000      .000      .000      .000      .000      .000      .000
GR   1125.900    50.100  1125.100    54.500  1124.000    54.700  1123.000    55.500  1122.600    56.200
GR   1122.600    58.000  1123.000    58.600  1124.000    59.400  1125.100    59.700  1125.100    61.900

NC       .000      .000      .070      .000      .000      .000      .000      .000      .000      .000
X1     23.000    10.000    54.500    59.700     1.000     1.000     1.000      .000      .000      .000
X3     10.000      .000      .000      .000      .000      .000      .000  1130.000  1129.800      .000
GR   1125.900    50.100  1125.100    54.500  1124.000    54.700  1123.000    55.500  1122.600    56.200
GR   1122.600    58.000  1123.000    58.600  1124.000    59.400  1125.100    59.700  1125.100    61.900

X1     22.000    18.000    58.100    94.100   100.000   100.000   100.000      .000      .000      .000
GR   1131.200      .000  1128.000    18.200  1127.600    37.600  1127.200    50.200  1125.400    58.100
GR   1125.100    66.000  1124.900    84.700  1125.600    94.100  1125.300    94.400  1125.200    95.200
GR   1125.500    97.000  1125.600    97.000  1125.400    98.900  1125.600   104.100  1125.700   113.000
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GR   1127.300    117.300   1129.900    128.100   1131.600    143.100       .000       .000       .000       .000

NC       .060       .060       .070       .100       .300       .000       .000       .000       .000       .000
X1     21.000     21.000    180.000    200.900    355.000    355.000    355.000       .000       .000       .000
GR   1134.900       .000   1133.400     21.700   1133.100     57.600   1131.900     69.900   1130.200     88.000
GR   1130.300     91.500   1130.100     98.200   1130.300    108.400   1130.500    121.600   1130.000    148.500
GR   1129.800    165.900   1129.800    170.600   1130.000    180.000   1128.300    184.600   1127.900    193.800
GR   1127.500    194.300   1127.500    195.400   1127.800    196.000   1127.900    196.100   1129.200    200.900
GR   1129.200    206.500       .000       .000       .000       .000       .000       .000       .000       .000

X1     20.000     38.000    171.000    238.100    300.000    300.000    300.000       .940       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR   1138.500       .000   1135.900      9.500   1135.600     14.500   1135.600     21.200   1136.200     24.500
GR   1136.200     29.100   1135.500     31.200   1134.300     81.800   1134.300    107.800   1134.300    114.800
GR   1134.300    122.800   1134.500    141.100   1134.200    148.500   1132.000    155.900   1133.000    157.400
GR   1133.100    171.000   1131.300    180.200   1131.000    181.300   1131.000    183.500   1131.000    186.300
GR   1131.300    193.300   1131.600    211.400   1131.700    221.400   1132.400    238.100   1132.800    239.600
GR   1134.500    248.600   1133.900    251.800   1135.000    258.700   1135.800    288.100   1136.300    330.900
GR   1136.600    349.900   1136.600    354.300   1136.600    368.700   1136.600    374.900   1136.600    381.500
GR   1137.000    388.500   1137.600    422.800   1137.600    446.200       .000       .000       .000       .000

NC       .000       .000       .000       .300       .500       .000       .000       .000       .000       .000
X1     19.400     13.000    180.000    187.000     90.000     90.000     90.000       .000       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1137.100   1137.100       .000
GR   1133.100    171.000   1131.900    180.000   1131.900    180.200   1131.900    181.000   1131.900    182.000
GR   1131.900    183.000   1131.900    183.500   1131.900    184.000   1131.900    185.000   1131.900    186.000
GR   1131.900    186.800   1131.900    187.000   1133.000    193.300       .000       .000       .000       .000

NC       .000       .000       .030       .000       .000       .000       .000       .000       .000       .000
X1     19.300       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
BT     13.000    171.000   1137.100   1133.100    180.000   1137.100   1131.900    180.200   1137.100   1133.400
BT    181.000   1137.100   1134.600    182.000   1137.100   1135.300    183.000   1137.100   1135.600    183.500
BT   1137.100   1135.700    184.000   1137.100   1135.600    185.000   1137.100   1135.300    186.000   1137.100
BT   1134.600    186.800   1137.100   1133.400    187.000   1137.100   1131.900    193.300   1137.100   1133.000
1
  11-27-90      13:28:46                                                                                PAGE    3


X1     19.200       .000       .000       .000     33.700     33.700     33.700       .000       .000       .000
X2       .000       .000       .000       .000       .000       .000      1.000       .000       .000       .000

NC       .000       .000       .070       .000       .000       .000       .000       .000       .000       .000
X1     19.100       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1137.100   1137.100       .000

X1     18.000     38.000    230.000    244.100     60.000     60.000     60.000       .000       .000       .000
GR   1140.700       .000   1138.700      7.700   1135.700     18.900   1135.300     31.800   1135.100     37.000
GR   1135.100     42.100   1135.000     44.700   1135.800    123.700   1135.100    125.800   1136.000    130.800
GR   1135.400    131.600   1135.500    144.600   1135.500    148.100   1135.600    154.900   1136.400    191.800
GR   1136.200    213.900   1136.100    215.500   1135.300    229.700   1135.300    230.000   1133.700    234.100
GR   1132.700    235.200   1132.700    235.500   1132.900    237.000   1133.500    237.900   1133.800    241.600
GR   1134.700    244.100   1134.800    273.100   1134.800    302.400   1135.100    315.300   1136.600    323.400
GR   1137.100    355.000   1137.800    417.500   1138.500    457.900   1138.100    466.300   1138.700    493.600
GR   1138.800    500.100   1138.800    504.900   1139.800    545.300       .000       .000       .000       .000

NC       .000       .000       .000       .100       .300       .000       .000       .000       .000       .000
X1     17.000     22.000    166.700    181.500    450.000    450.000    450.000       .940       .000       .000
GR   1139.100       .000   1139.200      6.000   1139.300     11.000   1139.200     18.400   1139.200     24.700
GR   1139.800     46.900   1138.800     63.100   1138.800     89.100   1138.300    102.900   1138.400    110.900
GR   1138.100    127.900   1138.200    133.400   1138.100    138.900   1139.000    159.400   1136.800    166.700
GR   1134.900    168.600   1134.700    168.800   1134.500    172.900   1135.900    181.500   1137.000    210.000
GR   1137.500    230.000   1138.000    260.000       .000       .000       .000       .000       .000       .000

X1     16.000      8.000      5.000     12.500    290.000    290.000    290.000       .000       .000       .000
GR   1140.000       .000   1139.000      3.000   1138.000      5.000   1137.200      5.000   1137.200     11.500
GR   1138.000     12.500   1139.000     75.000   1140.000     85.000       .000       .000       .000       .000

NC       .000       .000       .000       .300       .500       .000       .000       .000       .000       .000
X1     15.400     15.000    160.500    170.700     50.000     50.000     50.000       .000       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1141.900   1141.900       .000
GR   1138.900    158.100   1137.700    160.500   1137.700    161.000   1137.700    162.000   1137.700    163.000
GR   1137.700    164.000   1137.700    165.000   1137.700    165.600   1137.700    166.000   1137.700    167.000
GR   1137.700    168.000   1137.700    169.000   1137.700    170.000   1137.700    170.700   1139.500    174.400

NC       .000       .000       .030       .000       .000       .000       .000       .000       .000       .000
X1     15.300       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
BT     15.000    158.100   1141.900   1138.900    160.500   1141.900   1137.700    161.000   1141.900   1138.500
BT    162.000   1141.900   1139.600    163.000   1141.900   1140.300    164.000   1141.900   1140.700    165.000
BT   1141.900   1140.900    165.600   1141.900   1140.900    166.000   1141.900   1140.900    167.000   1141.900
BT   1140.800    168.000   1141.900   1140.400    169.000   1141.900   1139.800    170.000   1141.900   1138.800
BT    170.700   1141.900   1137.700    174.400   1141.900   1139.500       .000       .000       .000       .000

X1     15.200       .000       .000       .000     27.300     27.300     27.300       .000       .000       .000
X2       .000       .000       .000       .000       .000       .000      1.000       .000       .000       .000

NC       .060       .060       .070       .000       .000       .000       .000       .000       .000       .000
X1     15.100       .000       .000       .000      1.000      1.000      1.000       .000       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1141.900   1141.900       .000
1
  11-27-90      13:28:46                                                                                PAGE    4


X1     14.000     44.000    247.500    260.100     30.000     30.000     30.000       .000       .000       .000
GR   1139.900       .000   1140.000     12.800   1140.200     24.600   1140.300     41.700   1140.300     48.500
GR   1140.400     55.800   1140.800    100.800   1140.800    121.900   1141.100    146.400   1141.000    163.700
GR   1141.500    204.300   1142.000    234.100   1141.800    236.600   1140.300    240.300   1140.000    240.600
GR   1139.800    247.500   1138.200    250.700   1137.800    253.600   1137.800    254.900   1138.200    256.500
GR   1139.000    258.100   1139.000    258.900   1139.600    260.100   1140.000    264.700   1140.200    265.000
GR   1141.200    269.900   1141.800    274.500   1142.000    282.200   1141.600    302.700   1141.600    307.800
GR   1141.600    313.500   1142.300    323.100   1142.100    336.600   1142.000    340.300   1142.100    353.000
GR   1142.300    373.100   1141.400    387.000   1141.500    392.400   1141.800    417.100   1142.500    440.100
GR   1144.200    499.500   1144.100    508.800   1145.100    517.700   1145.500    523.100       .000       .000

X1     13.000     51.000    663.000    682.000    140.000    140.000    140.000       .870       .000       .000
X3     10.000       .000       .000       .000       .000       .000       .000   1144.000   1144.000       .000
GR   1144.700       .000   1144.000     46.400   1143.300     80.600   1142.800     99.000   1140.600    217.600
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GR  1139.900   368.200  1140.400   445.000  1140.600   461.800  1140.900   504.800  1141.000   549.700
GR  1140.600   555.000  1140.400   555.200  1139.200   563.400  1139.300   570.200  1139.500   575.200
GR  1140.200   578.600  1140.400   620.800  1139.700   624.400  1139.700   628.400  1140.600   634.800
GR  1140.800   647.800  1139.700   651.800  1139.500   653.600  1139.700   654.600  1141.400   661.000
GR  1141.200   663.000  1139.400   669.000  1138.800   672.600  1137.900   673.600  1137.800   675.600
GR  1138.900   677.000  1139.600   679.200  1140.900   682.000  1141.300   688.000  1141.100   694.000
GR  1139.400   700.200  1139.400   703.400  1140.400   706.800  1141.400   724.600  1141.400   778.100
GR  1140.000   787.500  1141.900   806.400  1142.000   840.000  1142.000   850.700  1142.200   895.800
GR  1142.200   936.800  1142.400   992.000  1142.900  1057.400  1143.400  1102.900  1148.300  1123.600
GR  1148.900  1141.600      .000      .000      .000      .000      .000      .000      .000      .000

X1    12.400    10.000   467.200   475.700    40.000    40.000    40.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1143.100  1143.100      .000
GR  1141.300   463.400  1139.400   467.200  1139.400   467.210  1138.900   468.300  1138.800   471.200
GR  1138.700   473.100  1138.800   475.200  1139.800   475.690  1139.800   475.700  1141.100   477.300

X1    12.300      .000      .000      .000     1.000     1.000     1.000      .000      .000      .000
BT    10.000   463.400  1143.100  1141.300   467.200  1143.100  1139.400   467.210  1143.100  1142.300
BT   468.300  1143.100  1142.300   471.200  1143.100  1142.300   473.100  1143.100  1142.300   475.200
BT  1143.100  1142.300   475.690  1143.100  1142.300   475.700  1143.100  1139.800   477.300  1143.100
BT  1141.100      .000      .000      .000      .000      .000      .000      .000      .000      .000

X1    12.200    11.000   700.500   709.000     4.200     4.200     4.200      .000      .000      .000
BT    11.000   698.800  1143.100  1141.300   700.500  1143.100  1139.000   700.510  1143.100  1142.300
BT   702.000  1143.100  1142.300   702.800  1143.100  1142.300   704.800  1143.100  1142.300   708.990
BT  1143.100  1142.300   709.000  1143.100  1139.300   709.190  1143.100  1139.300   709.200  1143.100
BT  1139.300   712.700  1143.100  1139.700      .000      .000      .000      .000      .000      .000
GR  1141.300   698.800  1139.000   700.500  1139.000   700.510  1138.700   702.000  1138.600   702.800
GR  1138.800   704.800  1139.300   708.990  1139.300   709.000  1139.300   709.190  1139.300   709.200
GR  1139.700   712.700      .000      .000      .000      .000      .000      .000      .000      .000

X1    12.100      .000      .000      .000     1.000     1.000     1.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1143.100  1143.100      .000
1
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X1    10.400      .000   700.500   709.200    40.000    40.000    40.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1143.300  1143.300      .000

X1    10.300      .000      .000      .000     1.000     1.000     1.000      .000      .000      .000
BT    11.000   698.800  1143.300  1141.300   700.500  1143.300  1139.000   700.510  1143.300  1142.500
BT   702.000  1143.300  1142.500   702.800  1143.300  1142.500   704.800  1143.300  1142.500   708.990
BT  1143.300  1142.500   709.000  1143.300  1142.500   709.190  1143.300  1142.500   709.200  1143.300
BT  1139.300   712.700  1143.300  1139.700      .000      .000      .000      .000      .000      .000

X1    10.200     7.000   388.800   397.500    12.200    12.200    12.200      .000      .000      .000
BT     7.000   387.300  1143.300  1140.400   388.800  1143.300  1139.700   388.810  1143.300  1142.500
BT   395.200  1143.300  1142.500   397.490  1143.300  1142.500   397.500  1143.300  1139.600   399.600
BT  1143.300  1139.500      .000      .000      .000      .000      .000      .000      .000      .000
GR  1140.400   387.300  1139.700   388.800  1139.700   388.810  1139.700   395.200  1139.600   397.490
GR  1139.600   397.500  1139.500   399.600      .000      .000      .000      .000      .000      .000

X1    10.100      .000      .000      .000     1.000     1.000     1.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1143.300  1143.300      .000

X1     9.000    26.000   207.500   229.300    20.000    20.000    20.000      .900      .000      .000
GR  1147.900      .000  1145.500    10.700  1143.700    18.000  1143.700    22.100  1143.200    24.800
GR  1143.000    27.100  1142.700    32.000  1142.400    63.400  1142.500   101.300  1142.600   115.200
GR  1142.900   147.200  1142.700   179.900  1141.800   207.500  1140.000   213.800  1139.800   217.200
GR  1139.500   217.500  1139.500   219.700  1139.600   219.900  1141.400   229.300  1141.200   243.100
GR  1142.000   248.900  1142.000   253.400  1142.100   279.200  1142.300   296.100  1143.900   313.600
GR  1144.800   326.800      .000      .000      .000      .000      .000      .000      .000      .000

NC      .000      .000      .000      .100      .300      .000      .000      .000      .000      .000
X1     8.000    29.000   474.000   538.300   375.000   375.000   375.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1144.000      .000      .000
GR  1142.800      .000  1142.200    10.000  1142.600    35.600  1142.500    66.000  1142.900    79.800
GR  1142.500   121.400  1142.400   125.300  1142.800   163.800  1143.000   200.800  1142.700   249.300
GR  1142.900   260.100  1143.400   315.300  1143.500   372.100  1143.600   416.000  1143.600   449.600
GR  1143.400   474.400  1143.000   529.300  1141.500   532.600  1141.400   532.600  1141.400   534.800
GR  1141.900   535.100  1144.000   538.300  1144.200   548.500  1144.600   556.200  1145.600   593.300
GR  1147.900   628.100  1151.300   660.800  1151.700   676.100  1164.200   735.800      .000      .000

X1     7.000    25.000    25.900    48.000   360.000   360.000   360.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000      .000  1146.000      .000
GR  1150.500      .000  1147.800     3.400  1146.900     4.800  1145.400     7.200  1145.300     7.800
GR  1145.000     9.300  1145.000    25.900  1144.200    41.800  1143.900    42.500  1143.900    43.000
GR  1144.000    46.100  1144.000    46.500  1145.000    48.000  1145.300    81.400  1145.400   103.300
GR  1144.600   108.000  1144.300   112.800  1144.400   116.400  1145.100   119.700  1145.400   121.300
GR  1146.000   141.600  1149.900   166.600  1152.300   173.100  1154.600   178.400  1164.200   209.100

NC      .150      .150      .070      .000      .000      .000      .000      .000      .000      .000
X1     6.000    21.000    49.900    60.900   300.000   300.000   300.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000      .000  1149.000      .000
GR  1152.900      .000  1149.200    10.800  1149.100    11.700  1148.400    18.100  1147.000    29.300
GR  1147.000    49.900  1146.700    52.700  1146.400    53.200  1146.200    53.500  1146.300    56.800
GR  1146.300    56.900  1148.200    60.900  1148.100    86.200  1147.600   117.500  1147.300   118.400
GR  1147.400   124.100  1147.900   134.100  1148.700   138.100  1149.100   139.100  1159.600   154.600
GR  1165.800   163.100      .000      .000      .000      .000      .000      .000      .000      .000
1
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X1     5.000    17.000    12.400    19.600   290.000   290.000   290.000      .000      .000      .000
GR  1154.600      .000  1152.400     3.100  1150.200     6.000  1149.400    12.400  1149.000    13.200
GR  1148.700    13.400  1148.900    16.800  1149.000    17.400  1149.500    19.600  1150.100    23.200
GR  1151.500    46.400  1152.200    63.000  1153.000    94.300  1153.800   110.300  1156.100   120.800
GR  1157.900   126.200  1158.800   137.600      .000      .000      .000      .000      .000      .000

X1     4.000    21.000    58.500    68.200   350.000   350.000   350.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000      .000  1154.000      .000
GR  1158.300      .000  1156.300     3.200  1153.600     9.900  1153.000    40.100  1152.800    58.500
GR  1152.500    58.600  1152.100    58.700  1151.300    60.200  1151.700    66.100  1152.300    68.200
GR  1152.800    79.800  1152.900    84.000  1153.100   114.000  1153.100   127.400  1152.300   129.600
GR  1152.200   131.800  1152.300   134.600  1154.900   139.300  1157.500   144.100  1160.100   149.700
```

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GR  1163.600   158.100      .000      .000      .000      .000      .000      .000      .000      .000

X1     3.000    18.000    51.100    60.500   260.000   260.000   260.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1157.600  1157.500      .000
GR  1161.500      .000  1158.200     3.700  1157.800     6.700  1157.100    18.000  1155.600    26.400
GR  1155.300    45.400  1155.100    51.100  1154.300    53.500  1153.800    53.700  1153.700    55.700
GR  1154.100    58.400  1154.600    60.500  1156.100    78.400  1155.600    99.500  1155.200   108.500
GR  1155.100   117.600  1160.900   125.800  1161.300   128.500      .000      .000      .000      .000

NC      .000      .000      .000      .300      .500      .000      .000      .000      .000      .000
X1     2.400    19.000    44.900    57.600    10.000    10.000    10.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1157.600  1157.500      .000
GR  1156.800    37.000  1155.800    38.700  1154.600    43.700  1154.600    44.900  1154.600    44.910
GR  1154.600    45.700  1154.300    48.300  1154.200    49.500  1154.200    49.510  1154.200    49.790
GR  1154.200    49.800  1154.000    54.400  1154.000    54.500  1154.000    54.510  1154.000    54.790
GR  1154.000    54.800  1154.000    56.100  1155.300    56.110  1156.700    57.600      .000      .000

X1     2.300    19.000    44.900    57.600     1.000     1.000     1.000      .000      .000      .000
BT    19.000    37.000  1157.400  1156.800    38.700  1157.400  1155.800    43.700  1157.600  1154.600
BT    44.900  1157.600  1154.600    44.910  1157.600  1156.800    45.700  1157.600  1156.800    48.300
BT  1157.600  1156.800    49.500  1157.600  1156.800    49.510  1157.600  1156.800    49.790  1157.600
BT  1156.800    49.800  1157.600  1156.800    54.400  1157.500  1156.700    54.500  1157.500  1156.700
BT    54.510  1157.500  1156.700    54.790  1157.500  1156.700    54.800  1157.500  1156.700    56.100
BT  1157.500  1156.700    56.110  1157.500  1156.700    57.600  1157.500  1156.700      .000      .000
GR  1156.800    37.000  1155.800    38.700  1154.600    43.700  1154.600    44.900  1154.600    44.910
GR  1154.600    45.700  1154.300    48.300  1154.200    49.500  1156.800    49.510  1156.800    49.790
GR  1154.200    49.800  1154.000    54.400  1154.000    54.500  1156.700    54.510  1156.700    54.790
GR  1154.000    54.800  1154.000    56.100  1155.300    56.110  1156.700    57.600      .000      .000

X1     2.200      .000      .000      .000     6.700     6.700     6.700      .000      .000      .000
X2      .000      .000      .000      .000      .000      .000     1.000      .000      .000      .000

X1     2.100    19.000    44.900    57.600     1.000     1.000     1.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1157.600  1157.500      .000
GR  1156.800    37.000  1155.800    38.700  1154.600    43.700  1154.600    44.900  1154.600    44.910
GR  1154.600    45.700  1154.300    48.300  1154.200    49.500  1154.200    49.510  1154.200    49.790
GR  1154.200    49.800  1154.000    54.400  1154.000    54.500  1154.000    54.510  1154.000    54.790
GR  1154.000    54.800  1154.000    56.100  1155.300    56.110  1156.700    57.600      .000      .000
1
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X1     1.000    32.000    37.600    54.300    35.000    35.000    35.000      .000      .000      .000
X3    10.000      .000      .000      .000      .000      .000      .000  1157.600  1157.500      .000
GR  1161.700      .000  1160.300     2.600  1158.900     5.200  1158.500     5.600  1157.900     7.600
GR  1157.700     7.800  1157.800     8.300  1157.200    13.400  1156.900    21.300  1156.500    33.800
GR  1155.800    37.600  1155.700    38.100  1155.400    38.600  1155.000    47.800  1155.400    51.800
GR  1155.700    52.800  1155.800    54.300  1155.600    63.700  1155.600    70.300  1155.600    71.100
GR  1155.400    79.800  1155.500    88.500  1155.600    89.700  1155.900    95.400  1156.100    99.000
GR  1156.000    99.400  1156.600   101.100  1156.600   108.300  1156.600   114.200  1156.700   115.000
GR  1160.500   120.500  1161.100   125.900      .000      .000      .000      .000      .000      .000
EJ      .000      .000      .000      .000      .000      .000      .000      .000      .000      .000
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *PROF 1

 CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS

 CCHV=    .100 CEHV=    .300
 *SECNO 27.000
     27.00      2.60  1122.00  1120.62  1122.00  1122.00       .00       .00       .00  1120.70
       21.        3.       9.       9.      18.      22.       44.        0.        0.   1120.20
       .00       .16      .40      .21     .100     .070      .100      .000  1119.40     78.81
   .000296        0.       0.       0.        0       11         0       .00    64.79    143.60
0
 *SECNO 26.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     26.00      1.17  1122.37  1122.37      .00  1122.64       .27       .14       .08  1122.80
       21.        0.      17.       4.       0.       7.        4.        7.        6.   1122.00
       .02       .00     2.52     1.16     .100     .070      .100      .000  1121.20     10.23
   .048822      140.     140.     140.        0       18         0       .00    19.46     29.69
0
 CCHV=    .300 CEHV=    .500
 *SECNO 25.000
 3280 CROSS SECTION     25.00 EXTENDED       .29 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1130.00 ELREA=     1129.80

     25.00      2.70  1124.90  1123.84      .00  1125.07       .18      2.40       .03  1124.70
       21.        0.      21.       0.       0.      11.        0.        8.        7.   1124.70
       .04       .00     1.86      .00     .100     .070      .100      .000  1122.20     94.90
   .010823      120.     120.     120.        5       11         0       .00     5.20    100.10
0
 *SECNO 24.200
 3280 CROSS SECTION     24.20 EXTENDED       .30 METERS


 3370 NORMAL BRIDGE,NRD= 12 MIN ELTRD= 1129.50 MAX ELLC= 1127.30

     24.20      2.70  1124.90  1123.83      .00  1125.08       .17       .00       .00  1124.70
       21.        0.      21.       0.       0.      11.        0.        8.        7.   1124.70
       .04       .00     1.85      .00     .100     .030      .100      .000  1122.20     90.70
   .002105        1.       1.       1.        2       23         0     -2.43    14.80    105.50
0
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *SECNO 24.100

 3370 NORMAL BRIDGE,NRD= 10 MIN ELTRD= 1129.60 MAX ELLC= 1127.60

     24.10      2.36  1124.96  1124.23       .00  1125.21       .24       .10       .03  1125.10
       21.        0.      21.       0.        0.      10.        0.        8.        8.   1125.10
       .04       .00     2.18      .00      .100      .030     .100      .000  1122.60     54.52
   .003270       37.      37.      37.         2        23        0       .00     5.14     59.66
0
 *SECNO 23.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1130.00 ELREA=      1129.80

     23.00      2.37  1124.97  1124.23       .00  1125.21       .24       .01       .00  1125.10
       21.        0.      21.       0.        0.      10.        0.        8.        8.   1125.10
       .04       .00     2.18      .00      .100      .070     .100      .000  1122.60     54.52
   .017758        1.       1.       1.         0        19        0       .00     5.14     59.66
0
 *SECNO 22.000
     22.00       .99  1125.89  1125.44       .00  1125.91       .02       .63       .07  1125.40
       21.        0.      19.       2.        1.      28.        7.       11.       11.   1125.60
       .08       .22      .68      .29      .100      .070     .100      .000  1124.90     55.94
   .003221      100.     100.     100.         3        16        0       .00    57.58    113.52
0
 CCHV=    .100 CEHV=     .300
 *SECNO 21.000
     21.00      1.17  1128.67  1128.65       .00  1128.94       .27      2.96       .07  1130.00
       21.        0.      21.       0.        0.       9.        0.       18.       24.   1129.20
       .13       .00     2.30      .00      .060      .070     .060      .000  1127.50    183.58
   .054203      355.     355.     355.         2        11        0       .00    15.40    198.97
0
 *SECNO 20.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1133.10 ELREA=      1132.40

     20.00      1.10  1132.10  1131.69       .00  1132.12       .02      3.15       .02  1133.10
       21.        0.      21.       0.        0.      31.        0.       24.       34.   1132.40
       .25       .00      .67      .00      .060      .070     .060      .000  1131.00    165.52
   .004319      300.     300.     300.         7        11        0       .00    51.69    217.21
0
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 CCHV=    .300 CEHV=     .500
 *SECNO 19.400
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1137.10 ELREA=      1137.10

     19.40       .97  1132.87  1132.87       .00  1133.36       .49       .93       .23  1131.90
       21.        0.      21.       0.        0.       7.        0.       26.       37.   1131.90
       .26       .00     3.10      .00      .060      .070     .060      .000  1131.90    180.00
   .049369       90.      90.      90.         0        11        0       .00     7.00    187.00
0
 *SECNO 19.300

 3370 NORMAL BRIDGE,NRD= 13 MIN ELTRD= 1137.10 MAX ELLC= 1135.70

     19.30      1.02  1132.92  1132.88       .00  1133.39       .46       .02       .01  1131.90
       21.        0.      21.       0.        0.       7.        0.       26.       37.   1131.90
       .26       .00     3.01      .00      .060      .030     .060      .000  1131.90    172.38
   .011549        1.       1.       1.         0        15        0     -6.96    20.44    192.82
0
 *SECNO 19.200
 3280 CROSS SECTION     19.20 EXTENDED       .46 METERS


 3370 NORMAL BRIDGE,NRD= 13 MIN ELTRD= 1137.10 MAX ELLC= 1135.70

     19.20      1.56  1133.46  1132.88       .00  1133.66       .20       .19       .08  1131.90
       21.        0.      21.       0.        0.      11.        0.       26.       37.   1131.90
       .26       .00     1.98      .00      .060      .030     .060      .000  1131.90    171.00
   .003327       34.      34.      34.         2        15        0    -15.39    22.30    193.30
0
 *SECNO 19.100
 3280 CROSS SECTION     19.10 EXTENDED       .47 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1137.10 ELREA=      1137.10

     19.10      1.58  1133.48  1132.87       .00  1133.66       .19       .01       .00  1131.90
       21.        0.      21.       0.        0.      11.        0.       26.       37.   1131.90
       .26       .00     1.91      .00      .060      .070     .060      .000  1131.90    180.00
   .009806        1.       1.       1.         1        14        0       .00     7.00    187.00
0
1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST
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 *SECNO 18.000
     18.00      1.73  1134.43  1134.25       .00  1134.67       .25       .98       .03  1135.30
       21.        0.      21.       0.        0.      10.        0.       27.       38.   1134.70
       .27       .00     2.21      .00      .060     .070      .060      .000  1132.70   232.24
   .032395       60.      60.      60.         2        8         0       .00    11.10   243.34
0
 CCHV=    .100 CEHV=     .300
 *SECNO 17.000
     17.00      2.23  1136.73  1135.62       .00  1136.76       .03      2.07       .02  1136.80
       21.        0.      18.       3.        0.      23.        8.       36.       48.   1135.90
       .44       .00      .79      .39      .060     .070      .060      .000  1134.50   156.76
   .001741      450.     450.     450.         6       14         0       .00    34.10   190.86
0
 *SECNO 16.000
 7185 MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
     16.00      1.12  1138.32  1138.32       .00  1138.56       .23      1.29       .06  1138.00
       21.        0.      18.       3.        0.       8.        3.       42.       57.   1138.00
       .48       .76     2.27      .82      .060     .070      .060      .000  1137.20     4.35
   .027615      290.     290.     290.         0        8         0       .00    28.37    32.73
0
 CCHV=    .300 CEHV=     .500
 *SECNO 15.400
 3280 CROSS SECTION     15.40 EXTENDED       .20 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1141.90 ELREA=     1141.90

     15.40      1.39  1139.09  1138.45       .00  1139.20       .11       .61       .04  1137.70
       21.        0.      21.       0.        0.      14.        0.       43.       58.   1137.70
       .49       .00     1.48      .00      .060     .070      .060      .000  1137.70   160.50
   .006843       50.      50.      50.         3       14         0       .00    10.20   170.70
0
 *SECNO 15.300
 3280 CROSS SECTION     15.30 EXTENDED       .18 METERS


 3370 NORMAL BRIDGE,NRD= 15 MIN ELTRD= 1141.90 MAX ELLC= 1140.90

1
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     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


     15.30      1.38  1139.08  1138.46       .00  1139.22       .14       .00       .01  1137.70
       21.        0.      21.       0.        0.      13.        0.       43.       58.   1137.70
       .49       .00     1.64      .00      .060     .030      .060      .000  1137.70   158.10
   .002612        1.       1.       1.         2       15         0     -5.11    15.44   173.54
0
 *SECNO 15.200
 3280 CROSS SECTION     15.20 EXTENDED       .27 METERS


 3370 NORMAL BRIDGE,NRD= 15 MIN ELTRD= 1141.90 MAX ELLC= 1140.90

     15.20      1.47  1139.17  1138.46       .00  1139.29       .12       .07       .00  1137.70
       21.        0.      21.       0.        0.      14.        0.       43.       58.   1137.70
       .50       .00     1.55      .00      .060     .030      .060      .000  1137.70   158.10
   .002248       27.      27.      27.         2       15         0     -5.74    15.61   173.71
0
 *SECNO 15.100
 3280 CROSS SECTION     15.10 EXTENDED       .31 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1141.90 ELREA=     1141.90

     15.10      1.51  1139.21  1138.45       .00  1139.30       .10       .00       .01  1137.70
       21.        0.      21.       0.        0.      15.        0.       43.       58.   1137.70
       .50       .00     1.37      .00      .060     .070      .060      .000  1137.70   160.50
   .005308        1.       1.       1.         2       11         0       .00    10.20   170.70
0
 *SECNO 14.000
     14.00      1.63  1139.43  1139.03       .00  1139.59       .16       .25       .03  1139.80
       21.        0.      21.       0.        0.      12.        0.       44.       59.   1139.60
       .50       .00     1.76      .00      .060     .070      .060      .000  1137.80   248.24
   .015660       30.      30.      30.         2       15         0       .00    11.52   259.76
0
 *SECNO 13.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1144.00 ELREA=     1144.00

     13.00      2.78  1140.58  1139.53       .00  1140.64       .06      1.02       .03  1141.20
       21.        0.      21.       0.        0.      20.        0.       46.       61.   1140.90
       .54       .00     1.08      .00      .060     .070      .060      .000  1137.80   578.61
   .004197      140.     140.     140.         1        8         0       .00    14.14   592.74
0
1
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     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 *SECNO 12.400

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1143.10 ELREA=     1143.10

     12.40      2.03  1140.73  1139.72       .00  1140.82       .09       .17       .02  1139.40
       21.        0.      21.       0.        0.      16.        0.       47.       61.   1139.80
       .55       .00     1.33      .00      .060     .070      .060      .000  1138.70   467.20
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  .004220      40.      40.      40.        2       22        0      .00     8.50   475.70
0
 *SECNO 12.300

 3370 NORMAL BRIDGE,NRD= 10 MIN ELTRD= 1143.10 MAX ELLC= 1142.30

     12.30      2.04  1140.74  1139.72      .00  1140.82      .09      .00      .00  1139.40
       21.        0.      21.       0.       0.      16.       0.      47.      61.   1139.80
       .55       .00     1.32      .00     .060     .070     .060     .000  1138.70   464.53
   .004181        1.       1.       1.        0       18        0    -2.32    12.32   476.85
0
 *SECNO 12.200
 3280 CROSS SECTION     12.20 EXTENDED      1.05 METERS


 3370 NORMAL BRIDGE,NRD= 11 MIN ELTRD= 1143.10 MAX ELLC= 1142.30

     12.20      2.15  1140.75  1139.74      .00  1140.84      .09      .02      .00  1139.00
       21.        0.      21.       0.       0.      16.       0.      47.      61.   1139.30
       .55       .00     1.33      .01     .060     .070     .060     .000  1138.60   699.20
   .003837        4.       4.       4.        0       23        0    -5.80    13.50   712.70
0
 *SECNO 12.100
 3280 CROSS SECTION     12.10 EXTENDED      1.06 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      1143.10 ELREA=      1143.10

     12.10      2.16  1140.76  1139.74      .00  1140.85      .09      .00      .00  1139.00
       21.        0.      21.       0.       0.      16.       0.      47.      61.   1139.30
       .55       .00     1.33      .00     .060     .070     .060     .000  1138.60   700.50
   .003817        1.       1.       1.        0       11        0      .00     8.50   709.00
0
1
  11-27-90     13:28:46                                                                                    PAGE    14


     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *SECNO 10.400
 3280 CROSS SECTION     10.40 EXTENDED      1.21 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      1143.30 ELREA=      1143.30

     10.40      2.31  1140.91  1139.74      .00  1140.98      .08      .13      .00  1139.00
       21.        0.      21.       0.       0.      17.       0.      47.      61.   1139.30
       .56       .00     1.23      .00     .060     .070     .060     .000  1138.60   700.50
   .002933       40.      40.      40.        0       11        0      .00     8.50   709.00
0
 *SECNO 10.300
 3280 CROSS SECTION     10.30 EXTENDED      1.21 METERS


 3370 NORMAL BRIDGE,NRD= 11 MIN ELTRD= 1143.30 MAX ELLC= 1142.50

     10.30      2.31  1140.91  1139.72      .00  1140.99      .07      .00      .00  1139.00
       21.        0.      21.       0.       0.      17.       0.      47.      61.   1139.30
       .56       .00     1.20     1.16     .060     .070     .060     .000  1138.60   699.09
   .002827        1.       1.       1.        0       20        0    -6.28    13.61   712.70
0
 *SECNO 10.200
 3280 CROSS SECTION     10.20 EXTENDED      1.42 METERS


 3370 NORMAL BRIDGE,NRD=  7 MIN ELTRD= 1143.30 MAX ELLC= 1142.50

     10.20      1.42  1140.92  1140.52      .00  1141.11      .20      .07      .06  1139.70
       21.        0.      21.       0.       0.      11.       0.      48.      62.   1139.60
       .56       .00     1.96      .00     .060     .070     .060     .000  1139.50   387.30
   .014254       12.      12.      12.        2       19        0    -4.18    12.30   399.60
0
 *SECNO 10.100
 3280 CROSS SECTION     10.10 EXTENDED      1.43 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      1143.30 ELREA=      1143.30

     10.10      1.34  1140.94  1140.52      .00  1141.13      .19      .01      .00  1139.70
       21.        0.      21.       0.       0.      11.       0.      48.      62.   1139.60
       .56       .00     1.95      .00     .060     .070     .060     .000  1139.60   388.80
   .013930        1.       1.       1.        0       14        0      .00     8.70   397.50
0
1
  11-27-90     13:28:46                                                                                    PAGE    15


     SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *SECNO 9.000

 3265 DIVIDED FLOW

      9.00      1.79  1141.29  1140.64      .00  1141.36      .07      .19      .04  1141.80
       21.        0.      21.       0.       0.      18.       0.      48.      62.   1141.40
       .56       .00     1.18      .15     .060     .070     .060     .000  1139.50   188.37
   .006898       20.      20.      20.        2       15        0      .00    23.29   219.35
0
 CCHV=    .100 CEHV=    .300
 *SECNO 8.000
```

```
 3265 DIVIDED FLOW

 3280 CROSS SECTION      8.00 EXTENDED       .11 METERS


 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1144.00 ELREA=     1144.00

      8.00      1.51  1142.91  1142.60       .00  1142.92       .01      1.55       .01  1192.80
       21.        0.      21.       0.        0.      66.        0.       64.      111.   1144.00
       .89       .00      .32      .00      .060     .070      .060      .000   1141.40      .00
   .002759      375.     375.     375.        8       21         0       .00    236.93   536.64
0
 *SECNO 7.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1145.00 ELREA=     1146.00

      7.00      1.16  1145.06  1144.88       .00  1145.18       .12      2.23       .04  1145.00
       21.        0.      21.       0.        1.      13.        0.       78.      160.   1145.00
       .95       .37     1.57      .00      .060     .070      .060      .000   1143.90     9.03
   .024525      360.     360.     360.        3       14         0       .00     38.97    48.00
0
 *SECNO 6.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1147.00 ELREA=     1149.00

      6.00      1.67  1147.87  1147.35       .00  1147.90       .04      2.72       .01  1147.00
       21.        8.      13.       0.       21.      12.        0.       85.      172.   1148.20
      1.06       .39     1.05      .00      .150     .070      .150      .000   1146.20    22.32
   .004672      300.     300.     300.        5        6         0       .00     37.89    60.21
0
1
  11-27-90     13:28:46                                                                                                      PAGE   16


     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 *SECNO 5.000
      5.00      1.49  1150.19  1149.96       .00  1150.42       .22      2.46       .06  1149.40
       21.        1.      19.       1.        3.       9.        1.       92.      180.   1149.50
      1.10       .50     2.20      .48      .150     .070      .150      .000   1148.70     6.04
   .019808      290.     290.     290.        3       19         0       .00     18.72    24.77
0
 *SECNO 4.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1152.80 ELREA=     1154.00

      4.00      1.95  1153.25  1152.43       .00  1153.33       .07      2.90       .02  1152.80
       21.        2.      19.       0.        8.      16.        0.       98.      191.   1152.30
      1.18       .20     1.24      .00      .150     .070      .150      .000   1151.30    27.04
   .004517      350.     350.     350.        5       19         0       .00     41.16    68.20
0
 *SECNO 3.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1157.60 ELREA=     1157.50

      3.00      1.58  1155.28  1154.95       .00  1155.49       .21      2.12       .04  1155.10
       21.        0.      21.       0.        0.      10.        0.      103.      197.   1154.60
      1.22       .00     2.02      .00      .150     .070      .150      .000   1153.70    51.10
   .018931      260.     260.     260.        3       14         0       .00      9.40    60.50
0
 CCHV=    .300 CEHV=    .500
 *SECNO 2.400

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=     1157.60 ELREA=     1157.50

      2.40      1.54  1155.54  1154.93       .00  1155.64       .10       .12       .03  1154.60
       21.        0.      21.       0.        0.      15.        0.      103.      197.   1156.70
      1.22       .00     1.42      .00      .150     .070      .150      .000   1154.00    44.90
   .008207       10.      10.      10.        2       14         0       .00     11.46    56.36
0
 *SECNO 2.300

 3265 DIVIDED FLOW

1
  11-27-90     13:28:46                                                                                                      PAGE   17


     SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
     Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
     TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
     SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


 3370 NORMAL BRIDGE,NRD= 19 MIN ELTRD= 1157.40 MAX ELLC= 1156.80

      2.30      1.54  1155.54  1154.96       .00  1155.66       .11       .01       .01  1154.60
       21.        0.      21.       0.        0.      14.        0.      103.      197.   1156.70
      1.22       .00     1.49      .00      .150     .070      .150      .000   1154.00    39.74
   .015234        1.       1.       1.        0       19         0     -3.02     16.06    56.38
0
 *SECNO 2.200

 3265 DIVIDED FLOW


 3370 NORMAL BRIDGE,NRD= 19 MIN ELTRD= 1157.40 MAX ELLC= 1156.80

      2.20      1.65  1155.65  1154.96       .00  1155.75       .10       .09       .00  1154.60
       21.        0.      21.       0.        0.      15.        0.      103.      197.   1156.70
      1.22       .00     1.38      .00      .150     .070      .150      .000   1154.00    39.31
   .012227        7.       7.       7.        2       19         0     -3.58     16.61    56.49
0
```

```
 *SECNO 2.100

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      1157.60 ELREA=      1157.50

      2.10      1.68  1155.68  1154.93       .00  1155.76       .08       .01       .00  1154.60
       21.        0.      21.       0.        0.      16.        0.      103.      197.   1156.70
      1.22       .00     1.28      .00      .150     .070      .150      .000   1154.00    44.90
   .005987        1.       1.       1.         1       11         0       .00     11.61    56.51
0
 *SECNO 1.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE,ELLEA=      1157.60 ELREA=      1157.50

      1.00      1.02  1156.02  1155.84       .00  1156.18       .16       .37       .04  1155.80
       21.        0.      21.       0.        0.      12.        0.      103.      198.   1155.80
      1.23       .00     1.77      .00      .150     .070      .150      .000   1155.00    37.60
   .024341       35.      35.      35.         1        8         0       .00     16.70    54.30
0
1
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                                                                                       THIS RUN EXECUTED 11-27-90
 ******************************************************
   HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
   ERROR CORR -  01,02,03,04,05,06
   MODIFICATION -  50,51,52,53,54,55,56
   IBM-PC-XT VERSION AUGUST 1985
 ******************************************************


 NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


  BIGHILL CREEK

 SUMMARY PRINTOUT TABLE  150

        SECNO      XLCH     ELTRD     ELLC     ELMIN        Q       CWSEL     CRIWS       EG      10K*S       VCH      AREA     .01K

        27.000      .00       .00      .00   1119.40     21.00   1122.00   1120.62   1122.00      2.96       .40     83.62    12.21
 *      26.000   140.00       .00      .00   1121.20     21.00   1122.37   1122.37   1122.64    488.22      2.52     10.31      .95
        25.000   120.00       .00      .00   1122.20     21.00   1124.90   1123.84   1125.07    108.23      1.86     11.31     2.02
        24.200     1.00   1129.50  1127.30   1122.20     21.00   1124.90   1123.83   1125.08     21.05      1.85     11.35     4.58
        24.100    37.20   1129.60  1127.60   1122.60     21.00   1124.96   1124.23   1125.21     32.70      2.18      9.63     3.67
        23.000     1.00       .00      .00   1122.60     21.00   1124.97   1124.23   1125.21    177.58      2.18      9.64     1.58
        22.000   100.00       .00      .00   1124.90     21.00   1125.89   1125.44   1125.91     32.21       .68     34.95     3.70
        21.000   355.00       .00      .00   1127.50     21.00   1128.67   1128.65   1128.94    542.03      2.30      9.12      .90
        20.000   300.00       .00      .00   1131.00     21.00   1132.10   1131.69   1132.12     43.19       .67     31.31     3.20
 *      19.400    90.00       .00      .00   1131.90     21.00   1132.87   1132.87   1133.36    493.69      3.10      6.77      .95
        19.300     1.00   1137.10  1135.70   1131.90     21.00   1132.92   1132.88   1133.39    115.49      3.01      6.97     1.95
        19.200    33.70   1137.10  1135.70   1131.90     21.00   1133.46   1132.88   1133.66     33.27      1.98     10.62     3.64
        19.100     1.00       .00      .00   1131.90     21.00   1133.48   1132.87   1133.66     98.06      1.91     10.99     2.12
        18.000    60.00       .00      .00   1132.70     21.00   1134.43   1134.25   1134.67    323.95      2.21      9.51     1.17
        17.000   450.00       .00      .00   1134.50     21.00   1136.73   1135.62   1136.76     17.41       .79     30.96     5.03
 *      16.000   290.00       .00      .00   1137.20     21.00   1138.32   1138.32   1138.56    276.15      2.27     11.40     1.26
        15.400    50.00       .00      .00   1137.70     21.00   1139.09   1138.45   1139.20     68.43      1.48     14.23     2.54
        15.300     1.00   1141.90  1140.90   1137.70     21.00   1139.08   1138.46   1139.22     26.12      1.64     12.84     4.11
        15.200    27.30   1141.90  1140.90   1137.70     21.00   1139.17   1138.46   1139.29     22.48      1.55     13.52     4.43
        15.100     1.00       .00      .00   1137.70     21.00   1139.21   1138.45   1139.30     53.08      1.37     15.36     2.88
        14.000    30.00       .00      .00   1137.80     21.00   1139.43   1139.03   1139.59    156.60      1.76     11.92     1.68
        13.000   140.00       .00      .00   1137.80     21.00   1140.58   1139.53   1140.64     41.97      1.08     19.52     3.24
        12.400    40.00       .00      .00   1138.70     21.00   1140.73   1139.72   1140.82     42.20      1.33     15.81     3.23
        12.300     1.00   1143.10  1142.30   1138.70     21.00   1140.74   1139.72   1140.82     41.81      1.32     15.86     3.25
        12.200     4.20   1143.10  1142.30   1138.60     21.00   1140.75   1139.74   1140.84     38.37      1.33     15.81     3.39
        12.100     1.00       .00      .00   1138.60     21.00   1140.76   1139.74   1140.85     38.17      1.33     15.82     3.40
        10.400    40.00       .00      .00   1138.60     21.00   1140.91   1139.74   1140.98     29.33      1.23     17.12     3.88
        10.300     1.00   1143.30  1142.50   1138.60     21.00   1140.91   1139.72   1140.99     28.27      1.20     17.45     3.95
        10.200    12.20   1143.30  1142.50   1139.50     21.00   1140.92   1140.52   1141.11    142.54      1.96     10.72     1.76
        10.100     1.00       .00      .00   1139.60     21.00   1140.94   1140.52   1141.13    139.30      1.95     10.79     1.78
         9.000    20.00       .00      .00   1139.50     21.00   1141.29   1140.64   1141.36     68.98      1.18     18.05     2.53
         8.000   375.00       .00      .00   1141.40     21.00   1142.91   1142.60   1142.92     27.59       .32     65.90     4.00
         7.000   360.00       .00      .00   1143.90     21.00   1145.06   1144.88   1145.18    245.25      1.57     14.09     1.34
         6.000   300.00       .00      .00   1146.20     21.00   1147.87   1147.35   1147.90     46.72      1.05     33.11     3.07
         5.000   290.00       .00      .00   1148.70     21.00   1150.19   1149.96   1150.42    198.08      2.20     12.65     1.49
         4.000   350.00       .00      .00   1151.30     21.00   1153.25   1152.43   1153.33     45.17      1.24     23.83     3.12
         3.000   260.00       .00      .00   1153.70     21.00   1155.28   1154.95   1155.49    189.31      2.02     10.39     1.53
         2.400    10.00       .00      .00   1154.00     21.00   1155.54   1154.93   1155.64     82.07      1.42     14.79     2.32
         2.300     1.00   1157.40  1156.80   1154.00     21.00   1155.54   1154.96   1155.66    152.34      1.49     14.08     1.70
         2.200     6.70   1157.40  1156.80   1154.00     21.00   1155.65   1154.96   1155.75    122.27      1.38     15.23     1.90
         2.100     1.00       .00      .00   1154.00     21.00   1155.68   1154.93   1155.76     59.87      1.28     16.36     2.71
         1.000    35.00       .00      .00   1155.00     21.00   1156.02   1155.84   1156.18    243.41      1.77     11.89     1.35

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  11-27-90      13:28:46                                                                                      PAGE   20
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 BIGHILL CREEK

SUMMARY PRINTOUT TABLE  150

      SECNO      Q         CWSEL    DIFWSP    DIFWSX    DIFKWS    TOPWID     XLCH

      27.000     21.00   1122.00       .00       .00       .00     64.79       .00
*     26.000     21.00   1122.37       .00       .37       .00     19.46    140.00
      25.000     21.00   1124.90       .00      2.53       .00      5.20    120.00
      24.200     21.00   1124.90       .00       .01       .00     14.80      1.00
      24.100     21.00   1124.96       .00       .06       .00      5.14     37.20
      23.000     21.00   1124.97       .00       .01       .00      5.14      1.00
      22.000     21.00   1125.89       .00       .92       .00     57.58    100.00
      21.000     21.00   1128.67       .00      2.78       .00     15.40    355.00
      20.000     21.00   1132.10       .00      3.42       .00     51.69    300.00
*     19.400     21.00   1132.87       .00       .77       .00      7.00     90.00
      19.300     21.00   1132.92       .00       .06       .00     20.44      1.00
      19.200     21.00   1133.46       .00       .53       .00     22.30     33.70
      19.100     21.00   1133.48       .00       .02       .00      7.00      1.00
      18.000     21.00   1134.43       .00       .95       .00     11.10     60.00
      17.000     21.00   1136.73       .00      2.31       .00     34.10    450.00
*     16.000     21.00   1138.32       .00      1.59       .00     28.37    290.00
      15.400     21.00   1139.09       .00       .77       .00     10.20     50.00
      15.300     21.00   1139.08       .00      -.01       .00     15.44      1.00
      15.200     21.00   1139.17       .00       .08       .00     15.61     27.30
      15.100     21.00   1139.21       .00       .04       .00     10.20      1.00
      14.000     21.00   1139.43       .00       .22       .00     11.52     30.00
      13.000     21.00   1140.58       .00      1.15       .00     14.14    140.00
      12.400     21.00   1140.73       .00       .15       .00      8.50     40.00
      12.300     21.00   1140.74       .00       .01       .00     12.32      1.00
      12.200     21.00   1140.75       .00       .02       .00     13.50      4.20
      12.100     21.00   1140.76       .00       .00       .00      8.50      1.00
      10.400     21.00   1140.91       .00       .15       .00      8.50     40.00
      10.300     21.00   1140.91       .00       .01       .00     13.61      1.00
      10.200     21.00   1140.92       .00       .01       .00     12.30     12.20
      10.100     21.00   1140.94       .00       .02       .00      8.70      1.00
       9.000     21.00   1141.29       .00       .35       .00     23.29     20.00
       8.000     21.00   1142.91       .00      1.62       .00    236.93    375.00
       7.000     21.00   1145.06       .00      2.15       .00     38.97    360.00
       6.000     21.00   1147.87       .00      2.81       .00     37.89    300.00
       5.000     21.00   1150.19       .00      2.32       .00     18.72    290.00
       4.000     21.00   1153.25       .00      3.06       .00     41.16    350.00
       3.000     21.00   1155.28       .00      2.03       .00      9.40    260.00
       2.400     21.00   1155.54       .00       .26       .00     11.46     10.00
       2.300     21.00   1155.54       .00       .01       .00     16.06      1.00
       2.200     21.00   1155.65       .00       .11       .00     16.61      6.70
       2.100     21.00   1155.68       .00       .03       .00     11.61      1.00
       1.000     21.00   1156.02       .00       .34       .00     16.70     35.00
1
 11-27-90     13:28:46                                                                  PAGE    22


 SUMMARY OF ERRORS AND SPECIAL NOTES


CAUTION  SECNO=    26.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    26.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=    19.400  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    19.400  PROFILE= 1  MINIMUM SPECIFIC ENERGY

CAUTION  SECNO=    16.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=    16.000  PROFILE= 1  MINIMUM SPECIFIC ENERGY
1
 11-27-90     13:30:08                                                                  PAGE     1


                                                                 THIS RUN EXECUTED 11-27-90
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
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